PHYSIOLOGICAL AND ANTHROPOMETRICAL DIFFERENTIALS BETWEEN HIGH AND LOW PERFORMANCE VOLLEY-BALL PLAYERS

THESIS

SUBMITTED FOR THE AWARD OF THE DEGREE OF

Doctor of Philosophy

IN

PHYSICAL EDUCATION

BY

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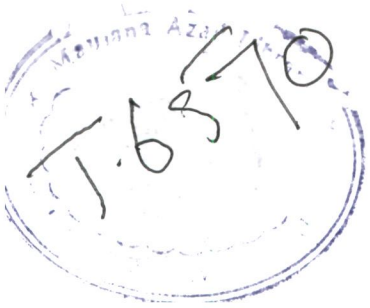
2005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Dedicated

to

My Father

(Late) Mohd. Zahid Hussain Khan

&

Mother

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Certificate

This is to certify that the thesis entitled, "***Physiological and Anthropometrical Differentials between High and Low Performance Volleyball Players***" is the original work carried out by **Mr. Mohd. Khalid Khan** under my supervision and is suitable for submission for the award of Degree of Doctor of Philosophy in Physical Education.

(Dr. Brij Bhushan Singh)
Supervisor

ACKNOWLEDGEMENT

First of all I would like thank the almighty Lord, who provided me with the opportunity and environment that I could complete my doctoral thesis.

Words are inadequate in translating deep sentiments of gratitude towards my respectable, sagacious, eminent and honourable supervisor ***Dr. Brij Bhushan Singh****. It has been a great honour and privilege to have worked under his apt and meffifluous guidance; his rich blend of knowledge and experience, perpetual interest, enlightened discussions, incessant encouragement, painstaking efforts and deep concern about my welfare, always influenced and guided me.*

I am also indebted to his wife, ***Mrs. Anuradha Singh*** *and his parents, who made me feel as a family member and which made it easy for me to approach my supervisor whenever I needed his advice.*

I am thankful to ***Dr. Jawaid Ali Khan****, Chairman, Deptt. of P.H. & S.E., A.M.U. for his great co-operation. He provided me with help, guidance, and inspiration at every step and with all the facilities needed for my research work.*

I am also grateful to the teaching staff of the Dept. of P.H. & S.E., A.M.U., which includes Dr. Rajendra Singh, Dr. Ikram Hussain, Mr. Kabir Shah Khan, Dr. Zamirullah Khan and Tariq Murtaza; my department colleagues Ekramullah Khan, Parvez Shamim, Ajay Rajput, Manzoor, Manju Lata, Saleem, for their co-operation and technical assistance from time to time.

I am also indebted to Mr. Avnish Yadav, Mr. Y. Subba Rao, Mr. Abhijeet Bhattacharya, Mr. Ratish, Mr. Mithilesh and other Indian volleyball players; Mr. Sardar Hussain, Coach, A.M.U. Volleyball Club; Mr. Jamshed and Mr. Imran, for their great help in collecting the data, without which my work would have been impossible.

I also wish to thank Mr. Amirullah Khan, Lecturer, Department of English, A.M.U. and Mohd. Khalid Khan for their proof reading. I am also thankful to my

friends Shalabh, Parvez, Iqtedar, Tanveer, Suhail, Sadre Alam, Suhail who always encouraged me and provided me with every kind of help.

No words can express my warm and heartfelt gratitude to my doting mother, Mrs. Rabia Khatoon; my adorable brothers, Shaukat Khan, Sarfaraz Khan, Maroof Khan; my loving sisters, Zarina, Parveen and Nasreen Khanam; my sisters-in-law and brothers-in-law; my nephews Salman, Haider, Tarique; my nieces Baby, Hena, Rumy, without whose prayers and ceaseless inspiration, this Herculean task could not have been completed.

A note of special thanks to my dearest wife, Aliya Shabnam for her sacrifice and constant encouragement which always restored my confidence.

I am also thankful to the non-teaching staff of my department especially, Mr. Anwar Ahmad Khan, Mr. Ashok Singh, Mrs. Chanda Parveen. and Mr. Wajahat Hashmi.

Last but not the least, I would thank Mr. H.K. Sharma for the pain he has taken to type this thesis.

(Mohd. Khalid Khan)

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Introduction

INTRODUCTION

Volleyball is a widely played game in India. It is played out door and indoor between teams, in which six members in each side seek to score points in the course of hitting a ball back and forth across the net within the playing area.

The history of volleyball game is not very old. William G. Morgan introduced it in 1895, when he was the Physical director for the Y. M.C.A. in Holyoke Mass in U.S.A.

He wanted to start a simple game that could be played by both fit and unfit. It also could be played almost anywhere. Basically this game was played for recreation. He divided a group into two teams and asked them to toss an inflated basketball bladder over a net; thus the game of volleyball was born. Its first name was "MINOTONETTE". Dr. A.T. Halsted of Springfield college later named it as volleyball because the ball has to be volleyed with hands, from one side to the other.

In its early form, minotonette required nine players, in three rows of three. Team rotation was a special feature ensuring that all players took turns in all positions on the court during the game. The full playing area was 50 ft. (15.24m) X25ft. (7.62m) divided by a net at a height of about 6 ft. 6 inch (2m).

At the 1896 YMCA conference the name of this new game was changed to volleyball. Later, the height of net was increased to 7 ft. and 6 inches (2.28m) and the teams were reduced to six players. The court was slightly enlarged and a special light leather ball was introduced. Earlier the rules and regulations of the volleyball were very simple but later on they become very complicated.

Through YMCA it gained worldwide popularity. By then it was seen as a competitive sport along with an enjoyable leisure activity. The first attempt to

bring standardized organisation into volleyball came in 1936 during the Berlin Olympics. The first international volleyball tournament was held at the world university games in 1939. The war years then gave a boost to the game; many soldiers played volleyball during training, and many used it as a form of exercise and recreation while interned in prison camps.

In April 1947 FIVB (International volleyball federation), was formed with its head quarters in Paris and with 14 members (Belgium, Brazil, Czechoslovakia, Egypt, France, Holland, Hungary, Italy, Poland, Portugal, Romania, Uruguay, United states and Yugoslavia). The first world volleyball championship was held in 1949 at Prague (Czechoslovakia). Where Russia had beaten Czechoslovakia in the final. The first Asian volleyball championship was held at Tokyo (Japan) in 1955 and in this championship, India had beaten Japan in the final. Today there are approximately 202 member countries in the international volleyball federation and the sports has over 84 million registered players, making it world's major recreational sports.

Volleyball was introduced in India by the YMCA. The volleyball federation of India was formed in 1950 to coordinate the activities of various state associations and to promote this game at the national level, and almost all-state association became the member of it. An Indian team selected at Kolkata in 1952, had taken part in the world volleyball championship at Moscow but could not show better performance.

Since its introduction, the game had got wide popularity, it is played in each and every part of our country. Now this game stands in top priority list of SAI, the main reason for its popularity is that the game is very cheap requiring a ball, a net and a small playing area, making it the game of masses. Almost all schools, colleges, community centres are having volleyball courts, where people of both sexes and different age groups play this game for recreation and competitive purpose. It promotes health, body control, alertness, coordination and team spirit.

The length of the game varies. There is certainly no time limit for a game, but the number of sets dictates its length. Major international games, national league and cup matches are played over the best of five sets, while other local league games are generally the best of three. Coaches can call two 30-second (maximum) time-outs in each set. Order of play is decided by the toss of the coin. This ceremony involves the referee and the two-team captains. The winning team captain chooses either the right to serve first or has the choice of court. The team, line-ups and position of players are very important because the rotation of player forms a crucial part of volleyball. Players of both sides retain their position at their each service until a side-out. When the service changes to the next team, that team rotates its players one place in a clockwise direction. The team, which loses the service, does not rotate. You can therefore see that all players take a turn to serve. A different rotation order can be used for each new set and players on the substitute bench can be introduced into the game. Up to six substitutes may be used per set. Any player who joins the game during a set as a substitute can himself be substituted but only by the player he replaced in the first instance. Substitution must be made during a break in play and with the approval of the referee.

Following are the fundamental skills, which constitutes the volleyball game.

a) *Serve* b) *Pass* c) *Set* *d) Smash* *e) Block*

Serve

The player serves the ball from out side of his court into the opponent court. The greater stature in relation to large upper and lower extremities, with greater power may play a very vital role in effectively servicing in the opponents court.

Defence

Defences are mainly under arm, side arm and blocking. The players having larger upper extremities with powerful arms and greater wrist width are able to effectively execute these skills.

Boost

Boosting is setting the ball at an appropriate position in the air for spiking into the opponents court. It requires larger hand with powerful fingers.

Smash

Smashing is the most important skill in volleyball in which a player jumps up and powerfully smashes the ball in opponent's court. It requires greater stature, with greater upper & lower extremities with powerful limbs, which contributes in jump and powerful smash.

In spite of players like Subba Rao, Avanish Yadav, Abhigit Bhattacharya, Ratish, Mithlesh, Rahul S.Amavekar etc. having excellent physique at par with their international counterparts, India does not have a significant place in international volleyball. The selected players in the national team dominate low performers of India in all anthropometrical and physiological measurements. They are lighter in proportion to stature with shorter trunks, longer extremities, broader chest and hip, with lesser endomorphic and mesomorphic components and high ectomorphic component and also have greater musculo-skeletal tissue in the thigh and upper arm, wider knees, wider elbow and lesser body fat than their low performing counterparts.

Excellence in sports is, indeed, an aspect of complex human performance, which has several dimensions. Hence, several disciplines of sports science are required to work in a coordinated manner to explore the nature of sports performance and the process of its improvements. In the last few decades, several disciplines of sports sciences have been established. They are Kinanthropometry, Sports physiology, Sports medicine, Sports training,

Sports psychology, Sports pedagogy, Biomechanics etc. these sports sciences work as an integrated whole to give a superb sports performance.

There exist a qualitative and quantitative interface between one's structure and function. Structural variations in body segments affect the quality and quantity of movements. A specific type of body structure predisposes human body to advantage in the specific type of movements. Knowing this scientific interface between structure and movement is of paramount importance in deciding the limits of performance. The segmental length and breadth determines the leverage, possessed by the body (positions of fulcrum and various lengths of load and effort arms) which in turn affects the final out-come of force created by muscles and its ultimate exploitation for the purpose of motions.

The human physique differs in a thousand ways. It can be analysed by studying the size, shape, and form of an individual. For this purpose a set of selected anthropometrical measurements are taken. The inter group comparisons are made to understand the physical peculiarities of a population. From such body measurements, it is possible to estimate the distribution of fat, bone, and muscles in one's body. This seems to be more important in the case of volleyball players where the anthropometrical and physiological parameters play a vital role in the performance.

The measurements of different body dimensions and ratios are of great relevance to the physical activity, especially in sports. The anthropometric assessment of physique involves the use of carefully defined body landmarks, specific positioning of the subject and use of appropriate instruments. The measurements that are taken on an individual are highly objective and highly reliable in the hand of a trained anthropometrist. **Malina** pointed out that the biological or functional significance of many dimensions has not yet been adequately established.

Sports science has a long history of studying physique. **Sheldon *et al.*** used photoscopic and anthroposcopic methods to describe individual physique as three different Somatotype viz; (i) endomorphy (fatty: predominance of digestive organs, softness and roundness of contour throughout the body), (ii) mesomorphy (muscular: predominance of muscles, bones and connective tissues) and (iii) ectomorphy (predominance of surface area over body mass linearity. This method has basic shortcomings i.e., it does not quantify the various body dimensions, indices and ratios. The body profile technique of **Mc Ardle *et al.*** describes physique in terms of muscular and non-muscular components. The diversity in overall body dimensions can be compared among individuals or groups from that of reference man and reference woman.

The Competitive sports demand event specific physique and body composition to achieve the success. **De Garay *et al.*** concluded that top-level performance in a particular event demands a particular type of body size and shape, if other aspects are being similar. They showed high correlation between the body profile of an athlete and specific task (event) in which he/she excelled. Various other studies also suggest that different body sizes, shapes and proportions are beneficial in different physical activities. **Hirata** suggested that a nation with people whose general physique is limited to the characteristics of champions in certain events must concentrate their sports training on those specific events only. He also concluded that Japanese with small body-builds are best for gymnastics, long-distance running, boxing and weight lifting etc. whereas the Americans who are large and lean are best for basketball, volleyball, swimming, long jump, short and middle distance running.

Carter suggested that the athletes who wish to achieve success in sports at a high level should compare their physique with Olympic athletes. If the athlete's bodily structure is within the limit of the Olympians, he/she may achieve high performance subjected to the optimization of other factors. **Behnke** and **Royce** concluded that long distance runners are characterized by

excessive leanness, relatively small body size and a deficiency of arm girth compared to chest size and leg length. The anthropometric and compositional study on cross-country runners revealed that runners are characterized by a relatively large calf and small biceps and abdominal girths.

Body composition is an important morpho-physiological characteristic. The methodology for the measurement of body composition has been explained by several scientists. Fat fold measurement can provide fairly consistent and meaningful information related to body fat and its distribution. The sum of 'fat fold' is an indicator of relative degree of fatness among individuals. **McArdle *et al.*** pointed out that exercise-induced change in fat fold values can be evaluated either as absolute or on percentage basis. **Peterson** pointed out that body fat is a very personal datum and it is strongly recommended that this information be presented discreetly.

Various scientists have extensively studied the body composition of athletes. **Leasy *et al.*** concluded that physical performance in which whole body moves, primarily depends on lean body mass (LBM). They developed regression equation for calculating body composition from performance in various tests (pull ups, standing broad jump). **Arizkova** pointed out that the proportion of lean body mass to fat is an indicator of degree of fitness for performance.

Contrary to these reports, **Uppal** and **Ray** in their study on strength, body composition and performance of shot put and javelin throwers, concluded that there was no significant relationship in body density, lean body mass and body fat percentage to performance. **Agbonjinmi** also reported that measures of body-build and body composition of female college athletes have negative correlation with physical fitness index .It is well established that the athletes who are lean or less fatty but are heavy because of a well developed musculature, are superior in performance as compared to their fatty

counterpart. Athletes with greater fat percentage have increased energy demand owing to their inert weight of fat resulting in relatively poor performance.

McArdle *et al.* pointed out that athletes generally have physique characteristics unique to their specific sports. For example field event athletes have relatively large quantities of lean tissues and a high percentage of body fat whereas long distance runners have the least amount of lean tissue and fat mass. He also pointed out that football players are amongst the heaviest and leanest of all sports men. Lohman pointed out the errors involved in determining the body composition in children and youth prior to their age of chemical maturity (age 15 to 18 year for most). The fat free mass (FFM) is not stable in growing children and youths because water content decreases and body solids (bone density) increases in concentration until maturity.

Physique along with physiological factors played a significant role on the performance of basketball players which was confirmed by **Parvez Shamim** (2002), who conducted a study on High and Low performance basketball players in India and observed that the High performers have greater stature, sitting height, weight, femur biepic condyler diameter, humerus biepic condyler diameter, shoulder width, hip width, upper arm length, lower arm length, thigh length, lower leg length, biceps muscle girth, calf muscle girth, wrist width, hand length and total arm length. They were more meso-ectomorphic, had better segmental proportionalities than their low performing counter parts. Physiologically high performer had lower heart rate greater vital capacity with no difference in systolic and diastolic blood pressure than their low performer counter parts.

Thus we see that the size, shape and form of the players are known to play a significant role in the performance of sports persons. Numerous factors are responsible for the performance of volleyball players. Fundamental skills of volleyball like servicing, passing, setting, smashing and blocking, requires a specific type of physique having specific proportions with certain conditional

abilities, which can be seen in physiological variables such as vital capacity, heart rate and blood pressure. The purpose of this research work is to place the role of anthropometrical and physiological variables on the performance level of Indian volleyball players.

Statement of the problem

The Objectives of the study and the exhaustive survey of related literature had led the researcher to state the problem as ***"Physiological and Anthropometrical differentials between high and low performance volleyball players***".

Hypothesis

After contemplating various aspects of the study, it is hypothesised that significant difference will be observed between the anthropometrical and physiological variables of high and low performance volleyball players.

Delimitation

Keeping in view the resources at hand and various restrains, the study is delimited to following variables.

1. **High and low performance Indian volleyball players**

   High performers; All India inter-varsity winners, runners and national players.

   Low performers; District, state, zonal and inter-varsity players.

2. **Selected anthropometrical parameters**

Stature, sitting height, weight, femur biepic condyler diameter, humerus biepic condyler diameter, shoulder width, hip width, upper arm length, lower arm length, thigh length, lower leg length, biceps muscle girth, calf muscle girth, skin folds (*biceps, triceps, calf, suprailiac and sub-scapular skin folds*), wrist width, hand length, total arm length.

Somatotype – (Heath carter method, 1984).

Body Proportionality – It includes following indices –

* Sitting height-Stature index
* Lower arm length – Upper arm length index
* Hip width-Stature index
* Shoulder width-Stature index
* Ponderal index
* Total arm length – Hand length index
* Total arm length – Lower arm length index
* Total arm length – Upper arm length index
* Hand length – Wrist width index

3. Selected physiological parameters

* Blood pressure
* Vital capacity
* Heart rate

Significance of study

In India, choice of sports is determined by the child's interest, facilities available and popularity of the sports in that particular society. It is immaterial whether, his body structure is fulfilling the mechanical requirements of the game or not. If he chooses a wrong activity for which his body structure is not suited, a limit is set beyond which, his performance cannot be improved, however hard he and his coach may try.

The findings of our study are having theoretical as well as practical implications. It is showing us clear difference in majority of the anthropometrical and physiological variables of high and low performance

volleyball players of our country and thus indicating the performance limits decided by the undertaken variables of our study.

This research work shall in turn provide guidelines to our coaches, physical educationists, and sports scientists to select appropriate talent at an early age according to the inherited anthropometrical and physiological traits, comparable with model high performance volleyball players of our country. As talent selected at early childhood is the best period for nurturing the required neuro-muscular coordination for various volleyball skills.

Chapter - 2

Review of Literature

REVIEW OF LITERATURE

The Researcher had undergone a vast survey of related literature. He had appraised various journals, books, periodicals etc. related with various aspects of this study. The important studies having specific relevance with the undertaken study are cited below.

Hirata (1966) studied 116 Olympic volleyball players who were found to be tall and lean. Their average height was 183.8cm and weight 79kg respectively. Less rating of endomorphic component than the controls, considerably greater length of the trunk, broad shoulders and hips, greater size of hand span, larger chest, upper arm, thigh and calf circumference than the control. All the above characteristics mechanically help for better performance.

Lamp (1954) conducted a study on Junior high school boys and girls and found positive correlations between the volleyball playing ability and age, height, weight and strength.

Sodhi (1980) collected data of different levels of volleyballers and found that with increase in the standard of the game the average stature of the players was greater. This means tall players have a natural advantage in performance. However, the volleyballers are not as tall as the basketballers on the whole.

Sodhi and Sidhu (1984) noted that the players in the Indian national volleyball team dominated other groups in all anthropometric measurements. They were lighter in proportion to stature with proportionately shorter trunks, longer lower extremities, smaller chest, and narrow hips. The rating of endomorphic and mesomorphic components was lower, but that of ectomorphic component was higher in their case. They had greater musculo-skeletal tissue in the thigh relative to the upper arms and possessed wider knees relative to the elbows than players of lower standards however; the amount of body fat was least in them.

The state level volleyballers, when matched with the controls, showed almost the typical body characteristics as those of the national team players, but with a smaller degree of pronouncement than the latter.

Sodhi et al. (1990) conducted a study on the north Indian junior volleyball players aged between 16 to 18 years. The results were based on the cross-sectional data of 90 volleyball players and 94 control subjects. The data were divided age-wise into three subgroups of each category. The results of the study revealed that the volleyballers in each age group were significantly taller and heavier than the controls. But amongst volleyballers the difference in height were found to be statistically non-significant between the three age group. The possibilities of developing national and international level aspirants from amongst the players in the study were also discussed.

The volleyballers in each age group possessed considerably greater length of their trunk, broader shoulders and hips, wider humerus and femurs, greater size of hand span, larger chest, upper arm, thigh and calf circumference than the controls. The differences were statistically significant in most of the cases. The skin fold showed almost similar status except the biceps and sub-scapular skin folds showing significantly greater value than the controls in the 16 years age group. In somatotype the 16 years volleyballers were significantly more endomorphic than the controls of same age. But the other groups showed similar status. In mesomorphy the 16 and 18 years volleyballers were considerably better developed than the controls. On the other hand in ectomorphy the sporting children had lower score than the latter. On average, the volleyballers were found to be meso-ectomorph.

Phul et. al, (1982) determined the basic physical characteristics of male volleyball players and found that they were taller, heavier, had a higher body density and lean body weight and lower body fat. They also concluded that the volleyball players achieved greater absolute height in jump and reach and a greater jumping height above the standing reach. Considering as a percentage of the net height (2.43m for men and 2.24m for women measured from each court),

the absolute jump and reach values were 130% and 124% of the respective net heights.

John et al., (1988) studied the physique of elite volleyball players of different countries and found that among these volleyball groups, the U.S.A. group was tallest, heaviest and largest in measures of upper and lower limb lengths. The Korean group was largest in stem height and calf girth.

Mokha and Sidhu (1988) took anthropometric measurements of Indian female volleyball players having International level of participation. They found that the volleyballers were taller and heavier than the controls. The taller stature of volleyball players was mainly due to the longer lower extremity because the mean values of the sitting height in both the groups were almost comparable. Upper extremities were also longer for volleyball players and they also possessed broader shoulders, wider knees and wrist.

In similar study **Heimer, Misigoj and Medved (1988)** reported that the performance in volleyball was largely influenced by anthropometric parameters, leg explosive strength and anaerobic capacity.

Sodhi et al. (1987) studied the somatotype and body composition of one hundred twenty two different level volleyball players. They found average values of somatotype components for national, state, university and district level players. Different group of volleyball players exhibited significantly lesser amount of percentage of body fat than the controls.

Abel et. al, (1987) compared basketball players and volleyball players in selected anthropometric parameters. They found that the basketball players were significantly taller and having larger humerus diameter then the volleyball players. Volleyball players were found to be significantly taller than the non-athletes. The somatotype distribution of the subjects showed that both basketball and volleyball players were significantly more ectomorphic than non-athletes.

Pervez Shamim (2002) carried out a study to ascertain the difference between physical and physiological variables of high and low performance

basketball players and found that the high performance basketball players had greater height, weight, lower leg, thigh, upper arm and lower arm length. They had greater shoulder and hip width and greater calf and biceps muscle girth with greater diameter of humerus and femur biepic condyle. They are meso-ectomorph and their sitting height is greater than low performance basketball player. They had lesser sum of four-skin folds measurement than that of low performance basketball players.

High performance basketball player had better body proportionality in relation to mechanical advantage. They also had lesser heart rate and greater vital capacity. However there was no significant difference in the blood pressure of high and low performance basketball players.

Monyeki M. et al. (1988) designed a study to describe and compare the somatotype characteristics of first division college basketball players of South Africa with their counter parts in other parts of the world. College basketball players of Nigeria were reported to be mesomorphic, while Sam Diego state university players were reported to be ectomorphic. The rationale of the study was that regular participation brings somatotype similar to top basketball player in the world.

Sodhi (1980) studied the top-ranking national basketball players and found that with the increasing standard of the participants the average stature was greater. The top class teams in the world have a greater average height than the teams of lower standard. A significant correlation was seen between the stature and performance in the competition. The value of correlation was very high with the field basket scores. Thus greater the stature of a basketballer, the better will be his performance.

The Olympic basketball players are the tallest followed by the national team, the state level and district level players (Sodhi & Sidhu, 1984). The controls were shortest among all. In general there was a gradient of decreasing body viz from the national team players to states level players through the

district level players and the controls. The first mentioned were found to have proportionally long upper and lower extremities, shorter trunk, broader hips and more slender chest. The somatotype indicated that the rating of ectomorphic component was greater in the case of the state level players than in the case of other groups. However, it is interesting to note that the rating of mesomorphic component was not greater in these players. The Indian basketballer were, therefore, less muscular than their olympic counterparts. The lack of ecto-mesomorphic physique among Indian may be a limiting factor for their better performance in the international competitions.

In body composition, the basketballer had less of body fat than the controls. The state level players seemed to be less fatty, with more strongly developed knees and a better-developed musculature in the limbs.

Garay D.E. et al., (1974) observed that the Mexican Olympic basketballers were 189.1 cm tall and 79.7 Kg heavy. Many of their players were ectomorph or mesomorphs. One player had a rating of 1.5-2.5-5.6.

Carter (1970) reported a sample of ten USSR female basketball players somatotyped by Heath. They were found to be fairly tall (173.0 cm) and heavy (71.2kg), with a mean somatotype of 4.3-4.5-3.0. The close balance between endomorphy and mesomorphy and the lack of physiques dominant in ectomorphy characterised this sample.

Malhotra et al. (1972) studied functional capacity and body composition of the throwers, jumpers, sprinters and the middle and long distance runners. The jumpers were found to have a higher lean body mass with less fat content than the throwers who were tall and heavily built. The middle and long distance runners had highest and the throwers, the lowest maximum O_2 intake capacity values in terms of body weight and lean body mass. Similarly, the trackmen had lower maximum heart rate than the other groups of athletes. The jumpers and throwers had stronger muscle power however; the later were strong in arm and shoulder muscle strength too.

Cureton (1954) tested 55 middle age athletic champions and compared them with 400 middle-aged men and with normal young men. The founder champions were more mesomorphic (3-5-4), more linear-in glutial-and abdominal girths. They also had stronger dynamometric strengths and better cardiovascular tests.

Telka and his associates (1951) Studied 245 finish top ranking track and field athletes and wrestlers. They did not find any appreciable differences in respect of constitution among the athletes of different branches, except in certain extreme groups. However they found them different from the control sample. They stated that the material body build of a definite type did not appear to be a necessary prerequisite to the achievement of good athletic results. However during 1954, the same workers related the top-ranking track and field athletes's various body measurements to their performance. Throwers were tallest in this material and they seemed also to benefit most from their height. The correlation between the relative shoulder breadth (with stature) and performance was significant in throwers and long distance runners. The correlation between the relative shoulder breadth (with stature) and performance was positive and highly significant in the case of the throwers. The correlation between the relative chest circumference (with stature) and performance was negative and highly significant in the case of sprinters and positive and significant in case of throwers.

Vujovic D. and Lozovina V. (1999) examined the differences between two groups of elite athlete's anthropometrics measurements. The groups were from sports of water polo and rowing. Subjects were measured with set of 18 anthropometric measurements. Multivariate analyses on manifested measurements as well as on scores on latent dimensions were employed to analyse the differences between the groups. Differences were based on differences in measurements that can be attributed to muscle tissue and fat tissue, which were both in favors of water polo players. There were no differences in measurements of skeleton except for the measurements of bicristal

width and leg length. Different training procedures and different surroundings in which activities were taking place cause the differences. No differences in skeleton measurements were the consequence of the selection process.

Mokha R. and Sidhu L.S. from Punjabi university Patiala examined the six-skin fold measurements (biceps, triceps, forearm, Sub-scapular, suprailiac and calf) were made on 157 track and field athletes (42-throwers, 35- jumpers and 80-runners). The range of ability (Highest level) from states through intervarsity to district (lowest-level), 81 subjects acted as controls. The throwers possessed significantly more fat at all six measurements sites than the jumpers and runners. The jumpers and runners did not differ much from each other. With the increasing levels of competition a trend of an increase in fat was observed in throwers and a decrease in jumpers and runners.

Stepnica J. (1965) studied the relationship between somatotype and motor manifestation. The relationship between somatotype components and motor performance in adult is expressed by means of correction analysis. Youths were categorized into zones with regard to motor performance. The most physically efficient were in fourth zone with whom was recorded the best body posture and the high motor activity. There were more motor-talented individuals among them. Most of the children attending training in top sports centers are included in the fourth zone. The pupils included in the first (endomorphs) and the second (ectomorphs) zones score the lowest physical performance and appear to have poor body posture. It was concluded that somatotype is a morphological predisposition of motor and sports efficiency, as well as body posture.

Singh S.P. and Malhottra P. (1986) conducted a study on Indian national cyclists. Anthropometric measurements were taken on 34 male and 9 female Indian cyclists who were attending a national coaching camp at Patiala with a view to evaluate their body composition, morphology and somatotype. The measurements were taken in the mornings to avoid any possible effects of fatigue on height and other body dimensions. Body fat was calculated from skin

folds using the formulae devised by Durnin and Womersley (1974) and somatotype were assessed by using the Heath and Carter (1967) method. The male and female cyclists were significantly heavier and possessed greater limb girths and skeletal diameters than their control counterparts. The percentage of body fat was similar in female cyclists and controls. The cyclists showed a greater development of musculo-skeletal tissue of the lower extremity relative to height than controls. The somatotypes of male and female cyclists were 2.76-3.90-3.21 and 5.17-3.22-2.56, respectively. Compared to the control groups, the cyclists of both sexes were more mesomorphic and stocky. Since the maximum share of the power transfer to the pedals is that of the lower extremities, therefore, highly developed muscles of calf, thigh, buttocks and hips of the cyclist seem to have a definite advantage.

Pavicic L. (1986) defined the degree of physical activity in sports events on the three samples of subjects. The sample with normal activity with moderate and versatile physical activity and the third group consist of elite athletes in water polo and rowing. Subjects were measured with a set of 18 anthropometric measures. The Hypothesis predicted significant difference between the given groups. The principal component analysis is used to analyse the differences on the talent structure. Studying the results of multivariate analysis of variance and discriminative analysis on the measure and on the scores of subjects on principal components, statistically significant difference between given groups can be stated. The difference in groups can be explained by recession and by the influence of training process.

Heath B.H. et. al. (1967) carried out a study to compare the genotypic and phenotypic photoscopic somatotype ratings of 54 young adults (23 males and 31 Females) aged 14-22 yrs. (Tanner and Whitehouse, 1982). Genotype rating was made by Tanner (T) criteria of Sheldon (1954). Phenotype ratings were made by heath (H) using the Heath and Carter (1967) method. Means for males were; age = 19.1yr; Somatotype (T) = 2.9 - 4.2 - 3.6; SAM. (T) = 1.9; Somatotype between somatotype means, somatotype by category. The r's were

0.91 (endomorphy), 0.78 (mesomorph) and 0.86 (ectomorphy). Means for female were; age = 18.2 yrs; Somatotype (T) = 4.7 - 2.8 - 3.7; SAM. (T) = 1.5; Somatotype (H) = 4.6 - 3.6 - 2.7; SAM. (H) = 1.6. There were difference between Somatotype means, Somatotype by category and H rating were higher than T rating. Component means were 0.80 (endomorphy), 0.46 (mesomophy), and 0.84 (ectomorphy). It is concluded that there are greater differences between methods for young females than males.

Cureton (1941) stated that in general people with long legs and long arms and relatively short and small trunks were physically weak types in long-sustained heavy work, but they might show great speed and endurance at high levels of athletic activity. Long third-class levers are noted for speed and range of action as well as their efficiency for force.

In another study by ***Sodhi et al. (1987)*** 97 Indian volleyball players were divided into four groups-National men (N = 12), State (N = 21), National University (N = 27) and District (N = 25) groups. The volleyballers in each group were compared with control group (N = 25), as well as the champion reported elsewhere. Each subject was examined with 12 anthropometric measurements and 10 tests of performance. The results of the study revealed the three groups of volleyball players and the controls, with a persistent decreasing gradient in most of the variables, in the order as mentioned.

In Somatotype the volleyballers on the whole possessed less rating of endomorphic component than the controls. Among volleyballers only district level players had shown significantly higher value of endomorphic component than that of the state. In the mesomorphic component the control sample showed rather higher rating than the volleyballers of each group. In the ectomorphic component volleyball players were observed to be more lean and thin than the controls. Contrarily among the different groups of volleyballers the ectomorphic component showed non-significant results with the sole exception of national volleyballers who scored more on ectomorphic scale than the state. However, on

average the volleyballers in each group were meso-ectomorphic in their somatotype.

In all the physical performance tests, except 2.4 km run the national players were the best, followed by the state, the university, the district players, and the controls with a descending gradient of performance. Overall the national level players were the best among the volleyball players and volleyballers as a whole were better than the controls in this regard. The information provided there in can be used as a criterion for evaluating the performance status of different levels of volleyballers in India.

Griffin made a study on heart rate of female field hockey and basketball players. He concluded that playing field hockey was more demanding in terms of heart rates than playing the basketball.

Puhl et al.(1982) conducted a study to examine the absolute and relative physical and physiological characteristics of elite men and women volleyball players. They tested eight members of U.S. men national team and 14 members of women university world game volleyball team. The Parameter measured indicated percent body fat, Vo_2 Max, post exercise blood Lactic acid measures of vertical jumping ability and peak isokinetic torque for knee flexion and extension shoulder extension and planter flexion at 80, 180, 240, and 300 degree per second and they established following findings (1) As expected, the men were taller, heavier had a higher body density and lean body weight and lower body fat, (2) For gross measures of jumping ability the men achieved greater absolute height for the standing reach.

The review of literature is reflecting the vast amount of work undertaken in this field, yet a cohesive work is not seen on over all physiological and anthropometrical parameters of volleyball players of our country. This study intends to undertake this task. This review has also provided us a definite guideline to objectively gather and evaluate the data, so that we are able to interpret our results in right perspective.

Chapter - 3

Procedure

PROCEDURE

In this chapter, selection of subjects as per the objectives of our study, tools and techniques employed for collecting the relevant data and statistical techniques applied for its analysis are described in detail.

SELECTION OF SUBJECTS

Keeping in view the objectives of our study 50 subjects each from high and low performance volleyball players of our country were selected.

High performance volleyball players; Were selected from;

- Senior national tournament held at "Choutal", Haryana in Nov. 2002
- All India inter-varsity championship finals held at "Ajmer" from 17th to 22 Nov., 2002.
- East & Northeast zone championship held at "Agra" from 16th to 21 Nov., 2002.

Low performance volleyball players; Were selected from;

- State championship held at "Moradabad" in October, 2002.
- North zone championship held at "Gadhwal" Uttranchal University, October, 2002.
- Inter-varsity tournament held at "Ajmer" in Nov., 2002.
- District tournament Moradabad ,2002.

CRITERIAN MEASURE

The criterion measures for this study were

* Weight	-	Kilogram
* Anthropometrical parameters	-	Centimeter and mm.
* Blood pressure	-	mm /Hg

* Vital capacity	-	Cubic centimeter
* Heart rate	-	Beats/minute
* Proportionality (indices)	-	Ratios
* Somatotype	-	Grading

INSTRUMENTS

The following instruments were used in collecting the data:

1) Anthropometric kit
2) Skin fold caliper
3) Sliding caliper
4) Measuring tape
5) Weighing machine
6) Stadio-meter
7) Sphygmomanometer
8) Stethoscope
9) Spiro meter
10) Stop watch

RELIABILITY OF DATA

Reliability of data was ensured by establishing the reliability of anthropometrical and physiological instruments and tester's competency.

Instruments reliability

Anthropometrical kit was used for obtaining anthropometric measurement and Sphygmomanometer, Stethoscope and Spiro meter were used for obtaining blood pressure and vital capacity respectively. Instruments were of standard quality; their accuracy was ensured by the manufacturer. International society for the advancements of Kinanthropometry (ISAK) approved techniques were

used for obtaining anthropometrical data. The reliability was checked by test-retest method and average co-efficient was found to be 0.96.

Tester competency

The investigator had a number of practice sessions under the expert guidance of Dr. Brij Bhushan Singh, Reader in the Department of Physical Health and Sports Education A.M.U., Aligarh. To ensure tester's competency the anthropometrical and physiological data of 10 students was correlated with the data taken by Dr. Rajender Singh Sr. Lecturer, Department of Physical Health and Sports Education A.M.U., Aligarh under similar conditions. The average co-efficient of the measurement taken by the investigator and expert was found to be 0.95.Thus; investigator's competency was established.

COLLECTION OF DATA

The volleyball players of the two categories were approached through coaches and managers of the teams participating in the above mentioned tournaments. The anthropometrical and physiological measurements were taken in the way described below.

(A) Anthropometric measurements

The delimited anthropometrical measurements of selected body parts of high and low performance volleyball players were taken in the following way.

1) Weight

The subjects were examined in clothing of known weight in order to record nude weight with the help of weighing machine.

2) Stature

Stature was taken as the maximum distance from the point vertex on the head to the ground. Subject was made to stand erect with heels together and arms hanging naturally by the side and head in the Frankfort plane, along a wall on which was fixed a measuring tape.

3) Sitting height

The subject was made to sit on the stool with his legs hanging down freely. The subject was asked to stretch his back as far as possible and hold his head up right so that Frankfort plane become horizontal gentle upward pressure was applied to the mastoid process. The muscles of the thigh and buttocks are contracted in order to stretch him full. The horizontal bar of the anthropometer rod was brought down so that it touched the highest point on the head. The distance between anthropometer rod and the highest point of the stool was measured.

4) Femur bi-epicondyler diameter

The subject was made to sit and the right leg was flexed at the Knee to form a right angle with thigh. The distance between medial and lateral epicondyler of the femur was measured with the help of sliding calliper and the value was recorded.

5) Humerus bi-epicondyler diameter

The subject's right arm was raised forward to the horizontal and the forearm flexed to right angle at elbow. The distance between medial and lateral epicondyler of the humerus was measured with the help of sliding caliper and the value was recorded.

6) Shoulder width

The subject was made to stand erect with the arms hanging loosely at the side. Sliding caliper was applied between the most lateral points on the acromion process. Caliper was applied from behind the subject and the branches of caliper were at of angle 45^0 from the horizontal plane.

7) Hip width

The subject was made to stand erect with sliding caliper applied from behind the subject, so that the branches of sliding caliper were at most lateral points on the superior border of the iliac crests.

8) Upper arm length

The subject was made to stand erect with arm hanging down normally with the palm of right hand directed towards the thighs. Interior border of acromion process and the external superior border of the hand of the radius were marked. The distance of these two points was measured with the help of measuring tape and value was taken.

9) Lower arm length

The subject was made to stand normally with arm hanging down normally. Radial and styallion were marked on right arm. The distance between these two points was measured with the help of measuring tape and value was taken.

10) Hand length (palm & fingers)

The subject was made to stand normally with arms hanging down. Right arm was made erect with palm and fingers directed towards thigh and then we measured the straight distance from the point stallion radial to dactylion 3, with the help of measuring tape.

11) Total arm length

The subject was made to stand normally with arms hanging down. Right arm with hand (Palm and Fingers) was made straight. Distance from Acrominon to Dactylion 3, with the help of measuring tape.

12) Wrist width

It means the width between the most medial and lateral points of the distal epiphyses of radius and ulna. The subject was made to sit with hand extended downwards and palm facing forward. The measurements were taken with sliding caliper at right angles to the axis of forearm, with firm pressure on the cross bars of sliding caliper.

13) Biceps skin fold

Vertical skin fold was measured at the anterior aspect of the right arm with arms hanging relaxed at the sides with right palm directed interiorly. The jaws of the calipers were applied to the fold and after waiting for 2 to 3 seconds the reading was taken. One more reading was taken in the same way and average of the two was the final score

14) Triceps skin fold

The mid acromiale-radial line on the posterior surface of the right arm was marked and the skin fold about one centimeter above marked level was picked up and jaws of the calipers were applied to the fold and after waiting for 2 to 3 seconds the reading was taken. One more reading was taken in the same way and average of the two was the final score.

15) Sub-scapular skin fold

A point below the right scapula was marked. The skin fold about one centimeter below marked level was picked up and jaws of the caliper were applied to the fold and after waiting for 2 to 3 seconds the reading was taken. One more reading was taken by the same procedure and average of the two was the final score.

16) Supra iliac skin fold

A point above the anterior superior iliac spine on the line to the anterior axillary's border of right side was marked. The skin fold about 2 to 5 centimeter above marked level was picked up and jaws of the caliper were applied to the fold and after waiting for 2 to 5 seconds the reading was taken. One more reading was taken by the same procedure and average of the two was considered.

17) Calf skin fold

The subject was made to sit on a chair with knees bent at right angles. Medial side of the right calf, slightly above the level of the maximum girth was marked. The skin fold above the marked level was picked up and jaws of the

caliper were applied to the fold. After waiting for 2 to 3 seconds the reading was taken. One more reading was taken by the same procedure and average of the two was considered.

18) Biceps muscles girth

The subject was made to raise his right arm to the horizontal position in the sagittal plane with the fully supinated forearm flexed at the elbow to an angle of 45°. The subject was encouraged to 'Make a muscle' by fully tensing his biceps. The measurement was taken with the help of measuring tape wrapped at right angles to the long axis of the upper arm where the maximum girth was affected.

19) Calf muscles girth

The subject was made to stand erect with body weight equally supported on both legs. The measuring tape was wrapped around the right lower leg and measurement was taken at right angles to the axis of lower leg where it was maximum.

20) Thigh length

The subject was made to stand erect with weight equally distributed on both legs. Trochanterion and tibial lateral of the right leg were marked. The distance between these two points was measured with the help of measuring tape.

21) Lower leg length

The subject was made to stand erect with weight equally distributed on both legs. Tibial of the right leg was marked. The distance between tibial and floor was measured with the help of measuring tape.

Somatotype

The following Heath Carter (1984) method was applied to determine somatotype of subjects;

Endomorphy

$$-0.7182 + 0.1451 \times *\Sigma SF - 0.00068 \times *\Sigma SF^2 + 0.0000014 \times *\Sigma SF^3$$

[Where SF = sum of triceps, sub-scapular and suprailiac skin folds multiplied by 170.18/height in centimeter].

Mesomorphy

0.858 × humerus breadth + 0.601 × Femur breadth + 0.188 × *corrected arm girth + 0.161 × *corrected calf girth – height × 0.131 + 4.5

(*Subtract the triceps skin fold and calfskin fold from the arm girth and calf girth, respectively).

Ectomorphy

The ectomorphy was determined by comparing the calculated height weight ratio (HWR) of the subject with the underlined values given below.

$$HWR = \frac{Heigth\,in\,cm}{\sqrt[3]{Weight\,in\,Kg}}$$

- If HWR is greater than or equal to 40.75 than ectomorphy = 0.732 * HWR – 28.58
- If HWR is less then 40.75 and greater than 38.25 then ectomorphy = 0.463 * HWR – 17.68
- If HWR is equal to or less than 38.25 than ectomorphy = 0.1

Proportionality

The following indices were used to determining various body segmental proportionalities.

- Sitting height-Stature index $= \frac{Sitting\ Height}{Stature} \times 100$
- Ponderal index $= \frac{Stature}{3\sqrt{Weight}}$
- Thigh length-Lower leg length index $= \frac{Thigh\ Length}{Lower\ leg\ length} \times 100$
- Upper arm length-Lower arm length index $= \frac{Upper\ arm\ length}{Lower\ arm\ length} \times 100$
- Hip width-Stature index $= \frac{Hip\ width}{Stature} \times 100$
- Shoulder width-Stature index $= \frac{Shoulder\ width}{Stature} \times 100$

(B) Physiological parameters

The selected physiological parameters were taken in the following ways–

1) Heart rate

The morning resting heart rate of the subject was taken. The subject was made to sit in resting position and semi-pronates the forearm and slightly flex the wrist. Three fingertips were placed on the radial artery at the lateral border of the wrist and the pulse was counted for one minute with the help of stopwatch.

2) Blood pressure

The morning blood pressure was taken. Subject was made to sit in resting position and the cuff of sphygmomanometer was wrapped around the upper arm. The stethoscope was placed lightly over the bronchial artery in the Cubital fossa. The pressure was increased in the cuff to 30 mm/Hg, above the level at which radial pulsation can no longer be felt. Then, the pressure was lowered in the cuff to 5 mm/Hg, at a time until the first sound of beat was heard. This was the systolic blood pressure and was recorded. The pressure was lowered further in

the cuff, until the sound became suddenly faint or inaudible. This was the diastolic pressure and was recorded.

3) Vital capacity

Subject was made to sit in resting position and the mouthpiece of Spiro meter was put into the mouth between the lips. The subject was asked to breathe normally. Then, he was asked to take deep breath following by rapid and full expiration. The two values were taken and mean of the values was noted down.

STATISTICAL PROCEDURE

Reiterating the objective of the study we have to point out that we intend to investigate the anthropometrical and physiological differentials between high and low performance volleyball players. Thus, Z test is used to test the significance of difference between physiological and anthropometrical parameters of high and low performance volleyball players. Z test is based on normal probability distribution and is used for judging the significance of several statistical measures, particularly the mean. It is the most frequently used test in research and is generally used for judging the significance of difference between means of two independent samples, when sample size is more than 30 (C.R. Kothari, 1998).

LEVEL OF SIGNIFICANCE

The differences in various variables of high and low performance volleyball players were tested at 0.05 level of significance.

Chapter - 4

Analysis of Data and Discussion of Findings

ANALYSIS OF DATA AND DISCUSSION OF FINDINGS

In this chapter analysis of data along with discussion of findings for each of the chosen variables of High and Low performance volleyball players is presented. Z test was used to test the significant difference between the chosen variables of high and low performance volleyball players

Table (1) - Weight

Weight in 'Kilogram' of High and Low performance volleyball players

Weight	High performance volleyball players	Low performance volleyball players
Mean	73.70	65.60
Standard Deviation	6.30	7.09
Obtained value $\|Z\|$	6.04*	
The mean of High performer is > than mean of Low performer by 12.35 %		

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 1 Shows significant obtained Z value for one tail test, which leads us to conclude that the mean weight, of high performance volleyball players is significantly greater (12.35%), than the mean weight of low performance volleyball players.

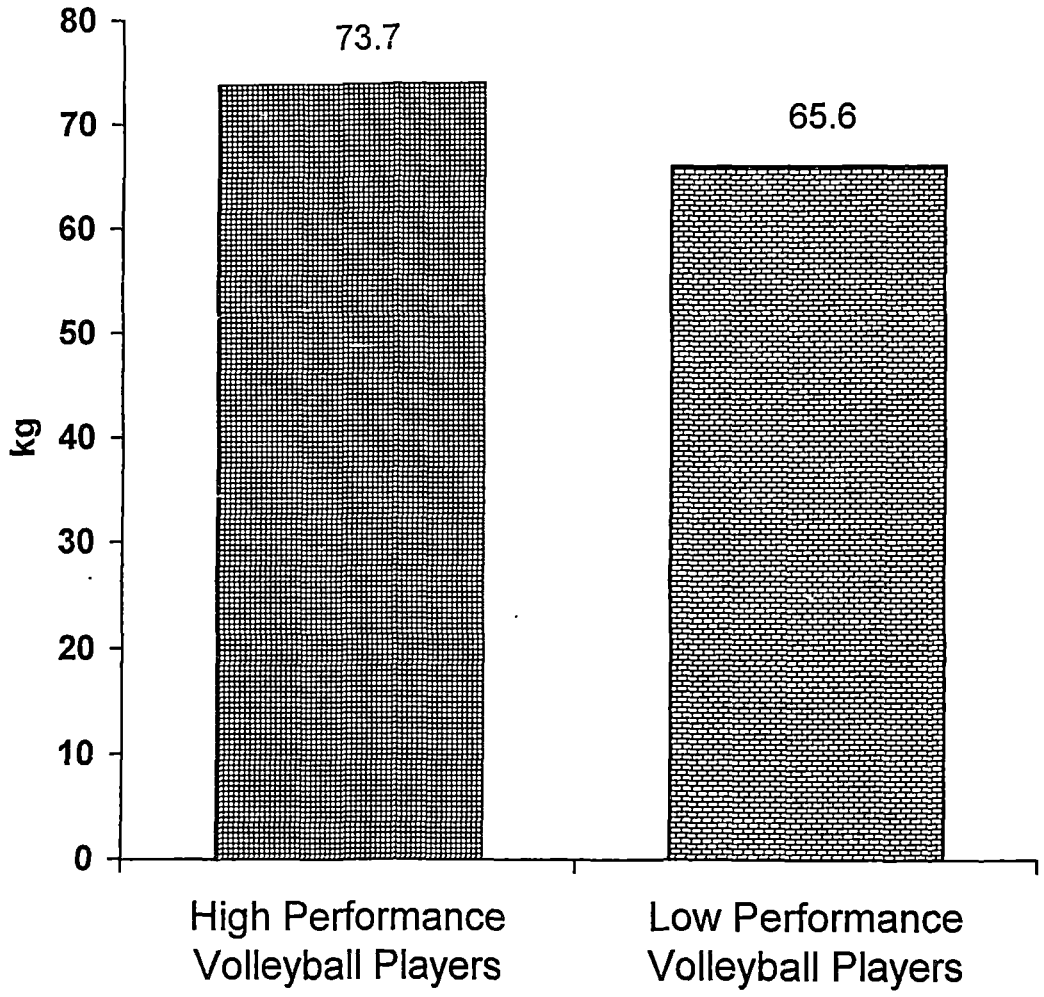

Fig.1. The mean weight of High and Low performance volleyball players

Table (2) - Stature

Stature in 'Centimeter' of High and Low performance volleyball players

Stature	High performance volleyball players	Low performance volleyball players
Mean	187.66	178.12
Standard Deviation	6.71	5.02
Obtained value $\|Z\|$	8.08*	
The mean of High performer is > than of mean Low performer $\overline{X}_1 > \overline{X}_2 = 5.36\%$		

* Significant at 0.05 level
** Z value for one tail test to be significant at 0.05 level 1.64

Table 2 Shows a significant obtained Z value for one tail test, which leads us to conclude that the mean stature of high performance volleyball players is significantly greater (5.36%) than the mean stature of low performance volleyball players.

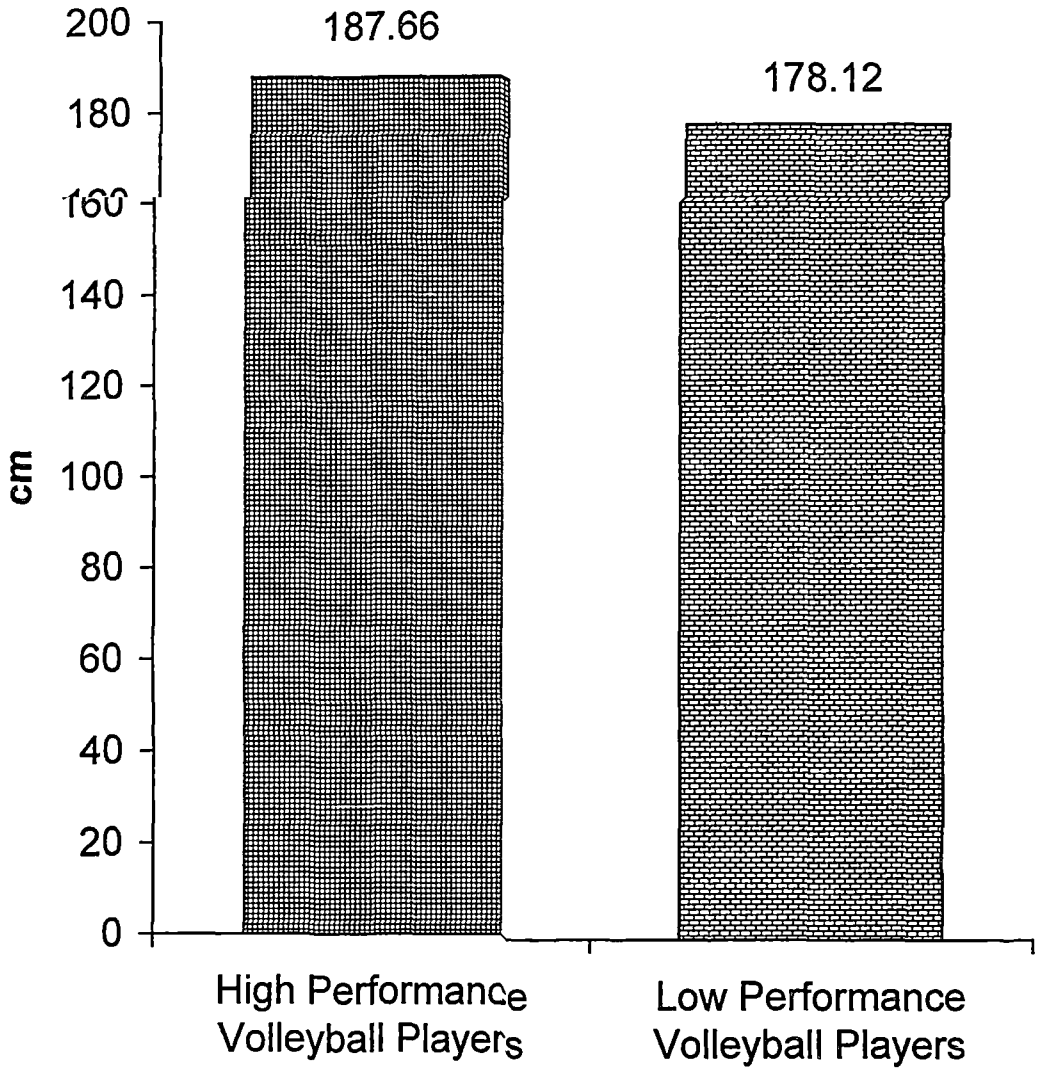

Fig.2: The mean Stature of High and Low performance volleyball players

Table (3) – Sitting height

Sitting height in 'Centimeter' of High and Low performance volleyball players

Sitting height	High performance volleyball players	Low performance volleyball players
Mean	93.20	89.20
Standard Deviation	4.09	3.26
Obtained value $\|Z\|$	5.48*	
The mean of High performer is > than of mean Low performer $\overline{X}_1 > \overline{X}_2 = 4.48\%$		

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 3 Shows significant obtained Z value for one tail test, which leads us to conclude that the mean sitting height of high performance volleyball players is significantly greater (4.48%) than the mean sitting height of low performance volleyball players.

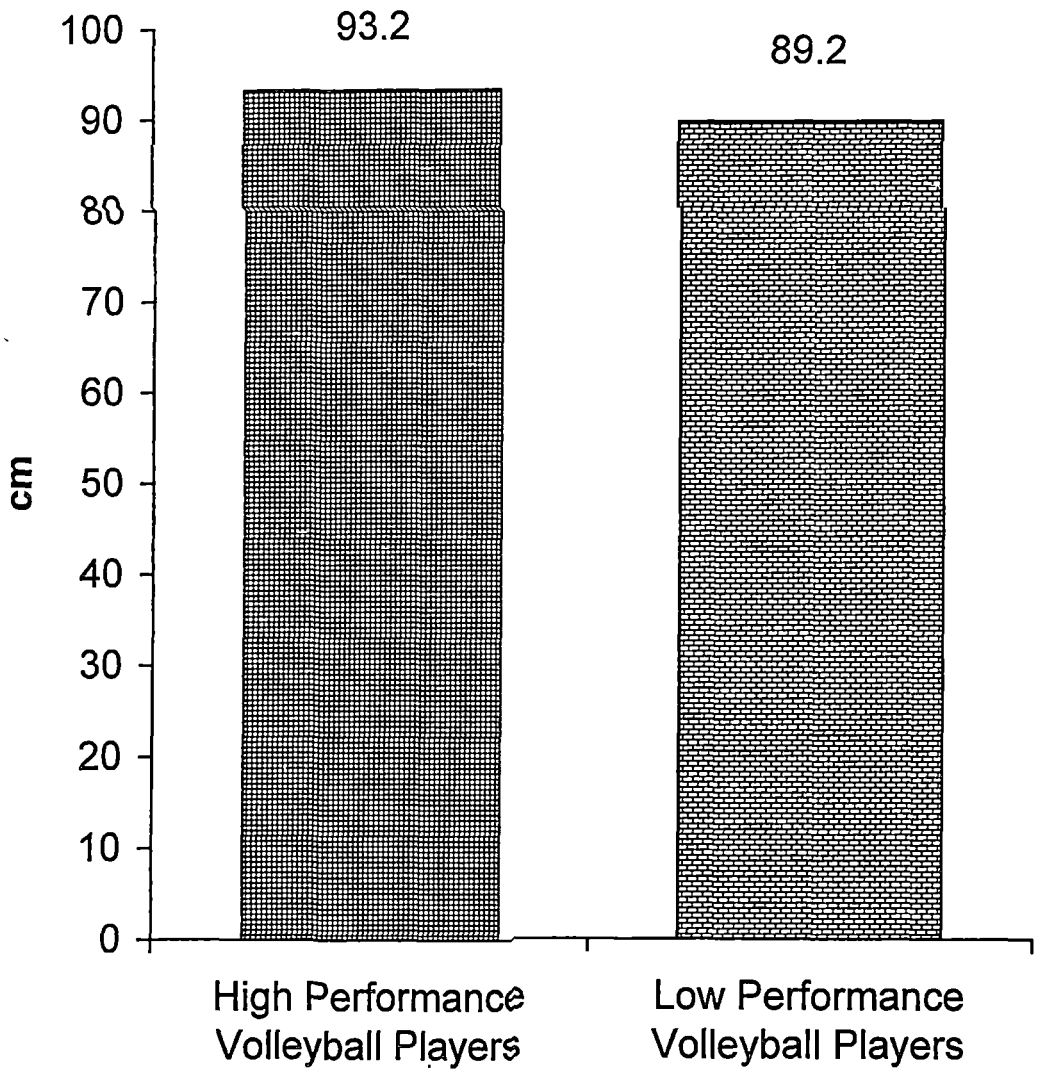

Fig.3: The mean Sitting height of High and Low performance volleyball players

Table (4) - Femur biepic condyle diameter

Femur biepic condyle diameter in 'Centimeter' of High and Low performance volleyball players

Femur biepic condyle diameter	High performance volleyball players	Low performance volleyball players
Mean	10.30	9.80
Standard Deviation	0.67	0.51
Obtained value $\|Z\|$	4.17*	
The mean of High performer is > than mean of Low performer $\overline{X}_1 > \overline{X}_2 = 5.10\ \%$		

* Significant of 0.05 level

*** Z value for one tail test to be significant at 0.05 level 1.64*

Table 4 Shows significant obtained Z value for one tail test, which leads us to conclude that the mean femur biepic condyler of high performance volleyball players is significantly greater (5.10%) than the mean femur biepic condyle diameter of low performance volleyball players.

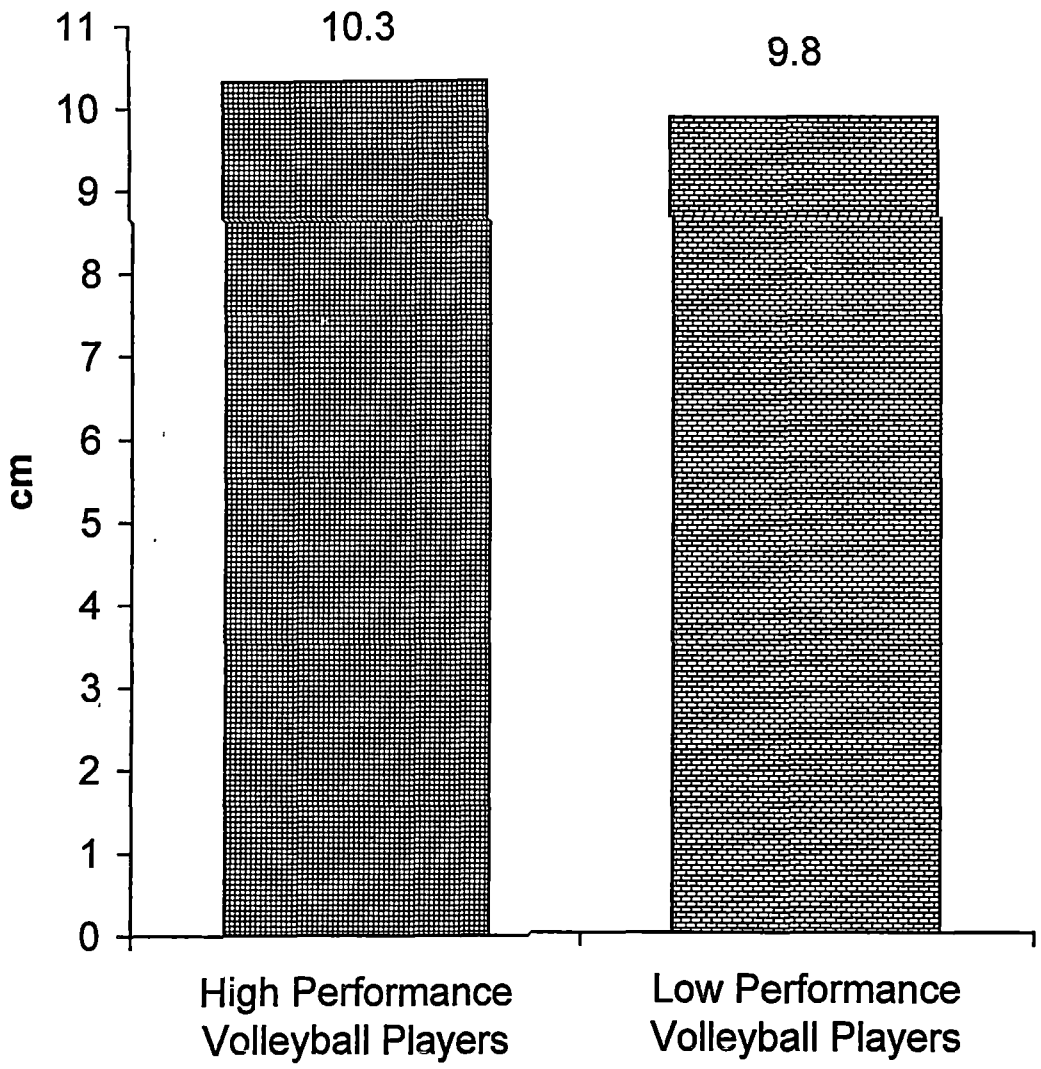

Fig.4: The mean Femur biepic condyle diameter of High and Low performance volleyball players

Table (5) - Humerus biepic condyle diameter

Humerus biepic condyle diameter in 'Centimeter' of High and Low performance volleyball players

Humerus biepic condyle diameter	High performance volleyball players	Low performance volleyball players
Mean	7.44	7.12
Standard Deviation	0.50	0.35
Obtained value $\|Z\|$	3.68*	
The mean of High performer is > than mean of Low performer $\overline{X}_1 > \overline{X}_2 = 4.49\%$		

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 5 Shows significant obtained Z value for one tail test, which leads us to conclude that the mean humerus biepic condyle diameter of high performance volleyball players is significantly greater (4.49%) than the mean humerus biepic condyle diameter of low performance volleyball players.

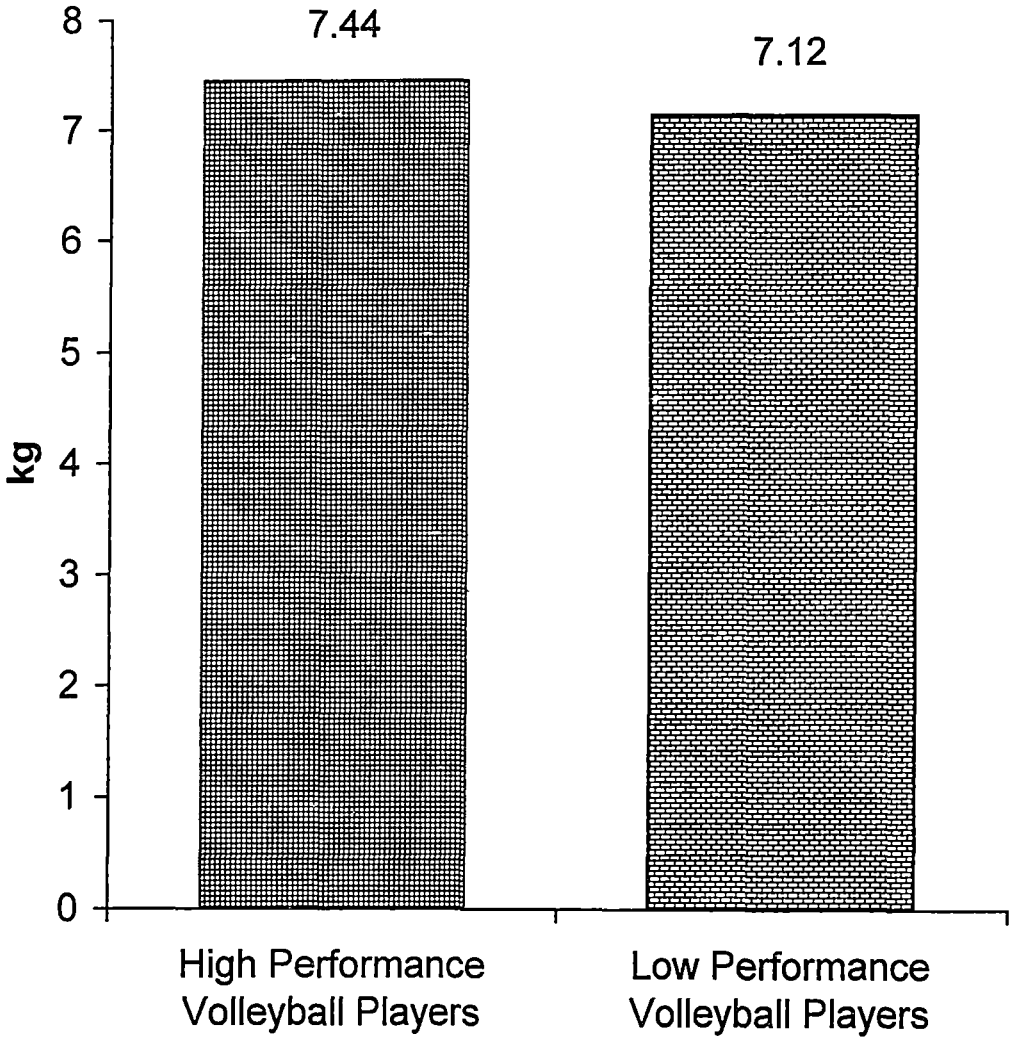

Fig.5: The mean Humerus biepic condyle diameter of High and Low performance volleyball players.

Table (6) - Shoulder width

Shoulder width in 'Centimeter' of High and Low performance volleyball players

Shoulder width	High performance volleyball players	Low performance volleyball players
Mean	41.80	39.50
Standard Deviation	1.60	6.94
Obtained value $\|Z\|$	4.86*	
The mean of High performer is > than mean of Low performer $\overline{X}_1 > \overline{X}_2 = 5.82\%$		

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 6 Shows significant obtained Z value for one tail test, which leads us to conclude that the mean shoulder width of high performance volleyball players is significantly greater (5.82%) than the mean shoulder width of low performance volleyball players.

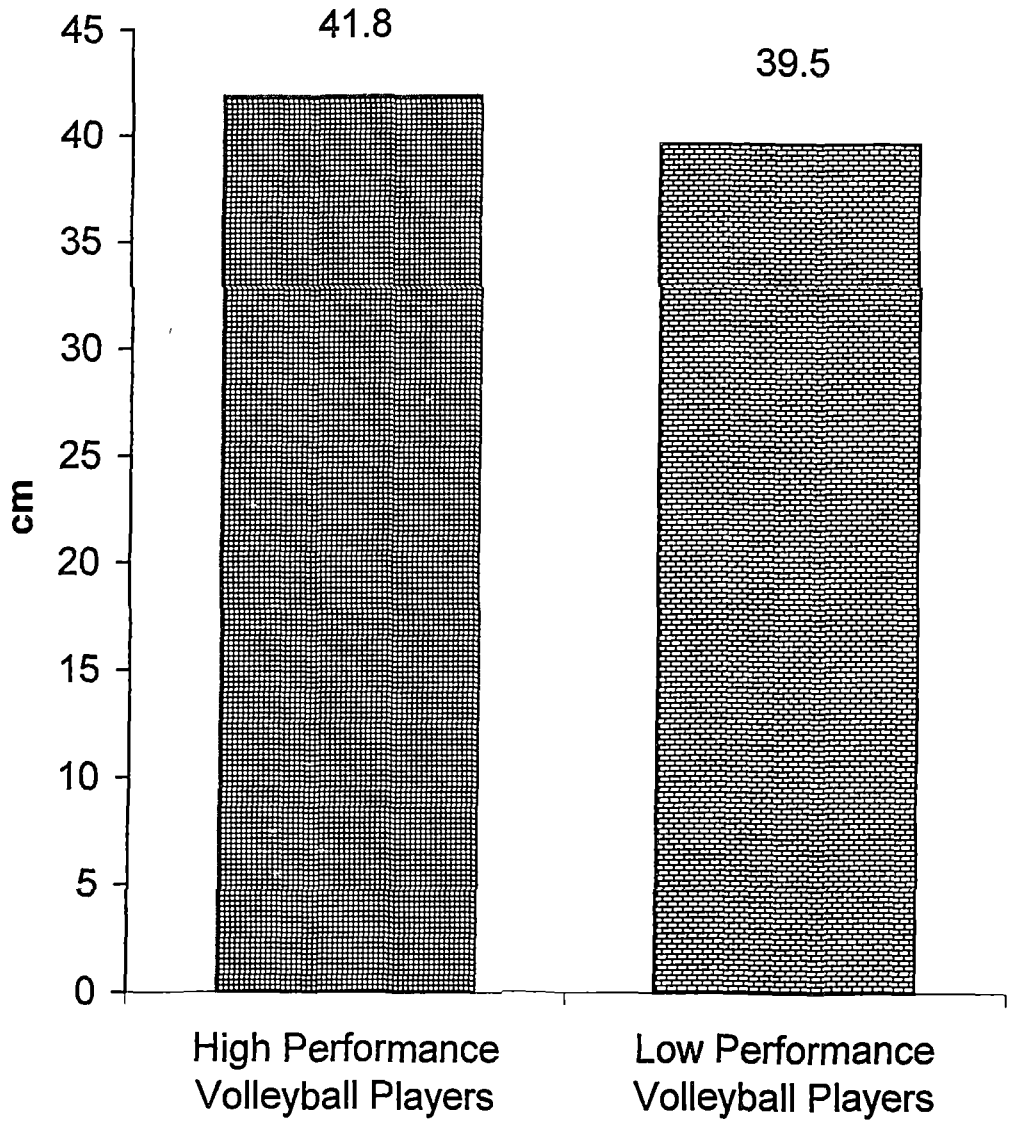

Fig.6: The mean Shoulder width of High and Low performance volleyball players.

Table (7) - Hip width

Hip width in 'Centimeter' of High and Low performance volleyball players

Hip width	High performance volleyball players	Low performance volleyball players
Mean	28.76	27.38
Standard Deviation	1.29	1.38
Obtained value $\|Z\|$	5.19*	
The mean of High performer is > than mean of Low performer $\overline{X}_1 > \overline{X}_2 = 5.04\ \%$		

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 7 Shows significant Z value for one tail test, which leads us to conclude that the mean hip width of high performance volleyball players is significantly greater (5.04%), than the mean hip width of low performance volleyball players.

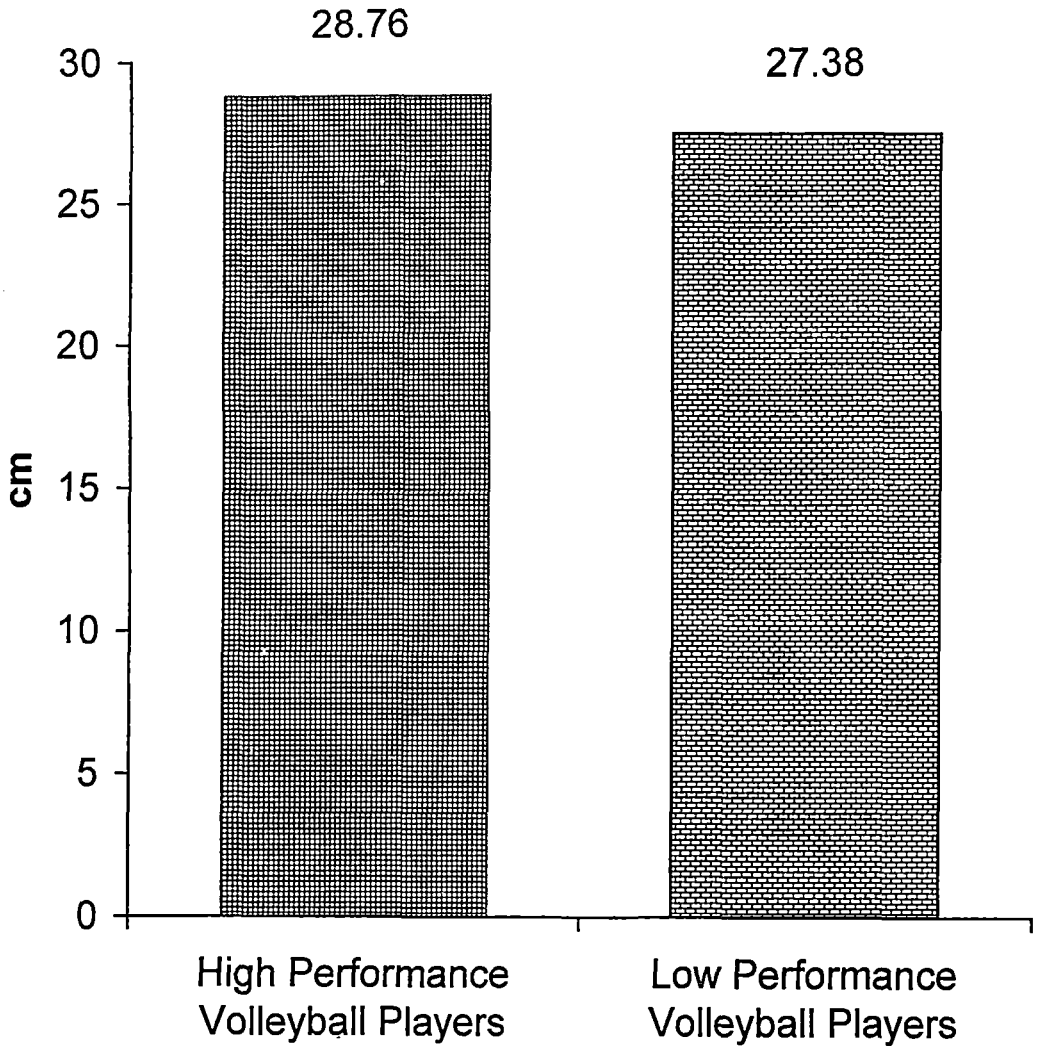

Fig.7: The mean Hip width of High and Low performance volleyball players

Table (8) - Upper arm length

Upper arm length in 'Centimeters' of High and Low performance volleyball players

Upper arm length	High performance volleyball players	Low performance volleyball players
Mean	35.74	33.84
Standard Deviation	2.70	2.36
Obtained value $\|Z\|$	3.79*	
The mean of High performer is > than mean of Low performer $\overline{X}_1 > \overline{X}_2 = 5.68\ \%$		

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level is 1.64*

Table 8 Shows significant obtained Z value for one tail test, which leads us to conclude that the mean upper arm length of high performance volleyball players are significantly greater (5.68%) then the mean upper arm length of low performance volleyball players.

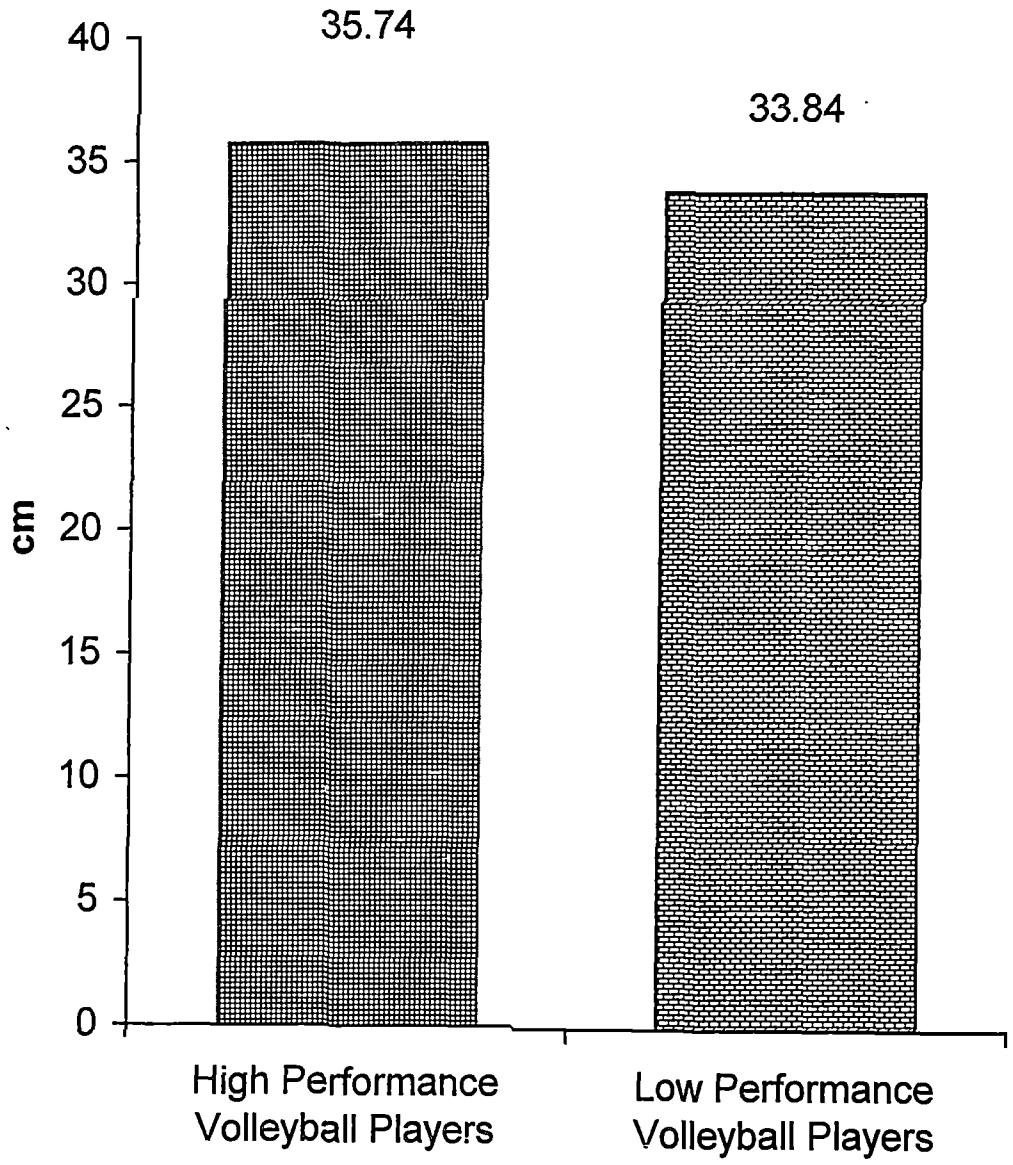

Fig.8: The mean Upper arm length of High and Low performance volleyball players

Table (9) - Lower arm length

Lower arm length in 'Centimeters' of High and Low performance volleyball players

Lower arm length	High performance volleyball players	Low performance volleyball players
Mean	29.20	27.42
Standard Deviation	2.14	1.34
Obtained value $\|Z\|$	4.94*	
The mean of High performer is > than mean of Low performer $\overline{X}_1 > \overline{X}_2 = 6.49\ \%$		

* *Significant at 0.05 level*
*** Z value for one tail test to be significant at 0.05 level is1.64*

Table 9 Shows significant obtained Z value for one tail test, which leads us to conclude that the mean lower arm length of high performance volleyball players is significantly greater (6.49%), than the mean lower arm length of low performance volleyball players.

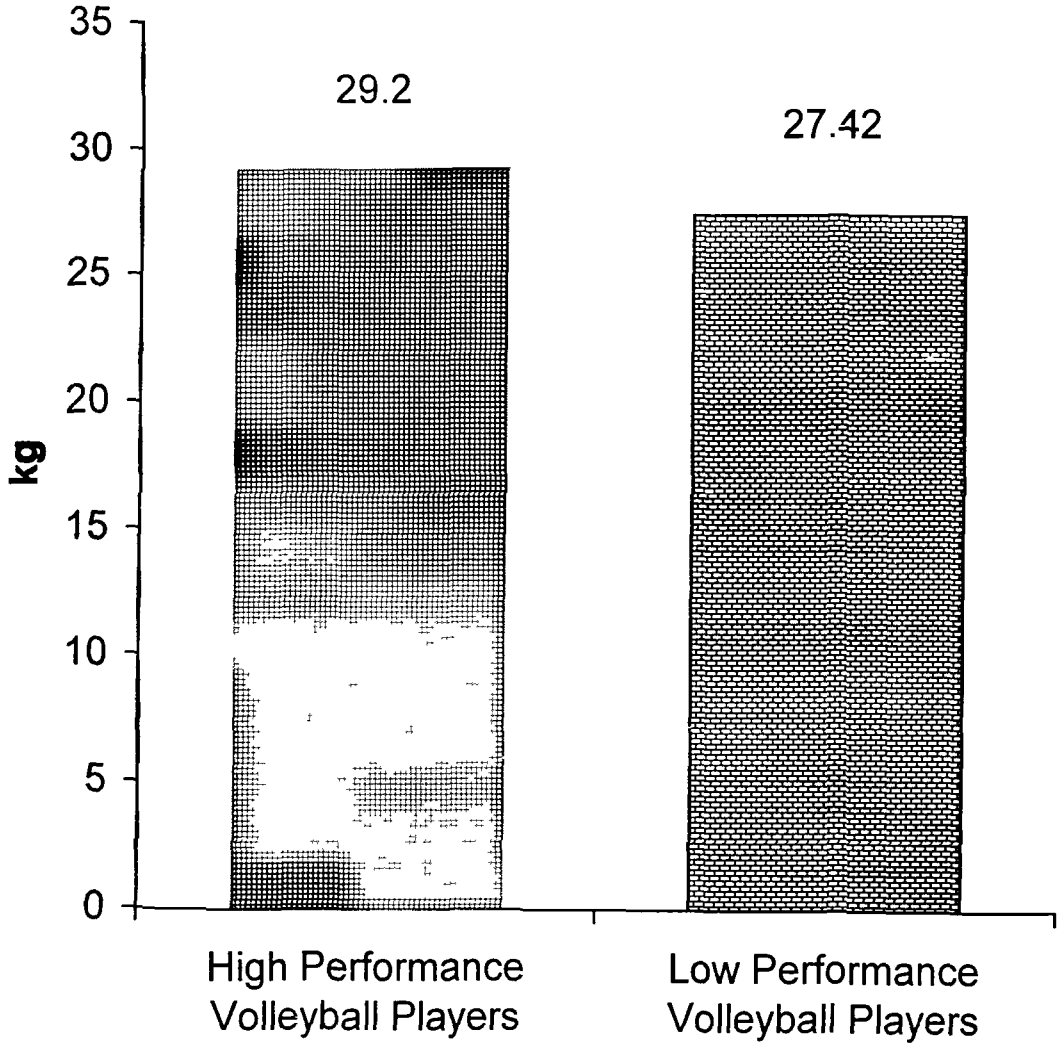

Fig.9: The mean Lower arm length of High and Low performance volleyball players

Table (10) - Thigh length

Thigh length in 'Centimeter' of High and Low Performance Volleyball Players

Thigh length	High performance volleyball players	Low performance volleyball players
Mean	48.24	45.18
Standard Deviation	3.08	1.96
Obtained value $\|Z\|$	5.88*	
The mean of High performer is > than mean of Low performer $\overline{X}_1 > \overline{X}_2 = 6.77\ \%$		

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 10 Shows significant obtained Z value for one tail test, which leads us to conclude that the mean thigh length of high performance volleyball players is significantly greater (6.77%), than the mean thigh length of low performance volleyball players.

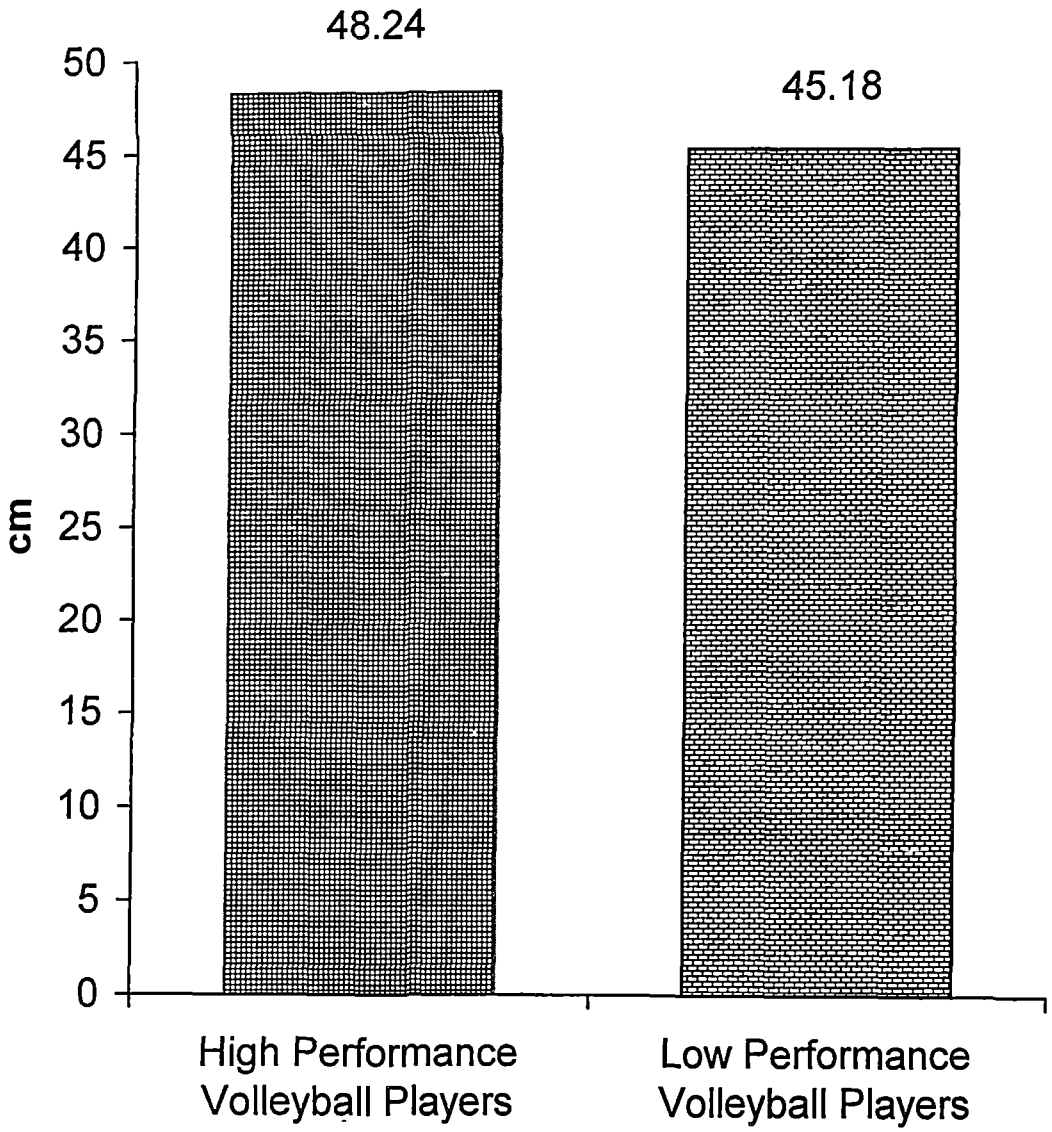

Fig.10: The mean Thigh length of High and Low performance volleyball players

Table (11) - Lower leg length

Lower leg length in 'Centimeter' of High and Low performance volleyball players

Lower leg length	High performance volleyball players	Low performance volleyball players
Mean	53.70	50.30
Standard Deviation	3.56	2.45
Obtained value $\|Z\|$	5.57*	
The mean of High performer is > than mean of Low performer $\overline{X}_1 > \overline{X}_2 = 6.76\ \%$		

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 11 Shows significant obtained Z value for one tail test, which leads us to conclude that the mean lower leg length of high performance volleyball players is significantly greater (6.76%), than the mean lower leg length of low performance volleyball players.

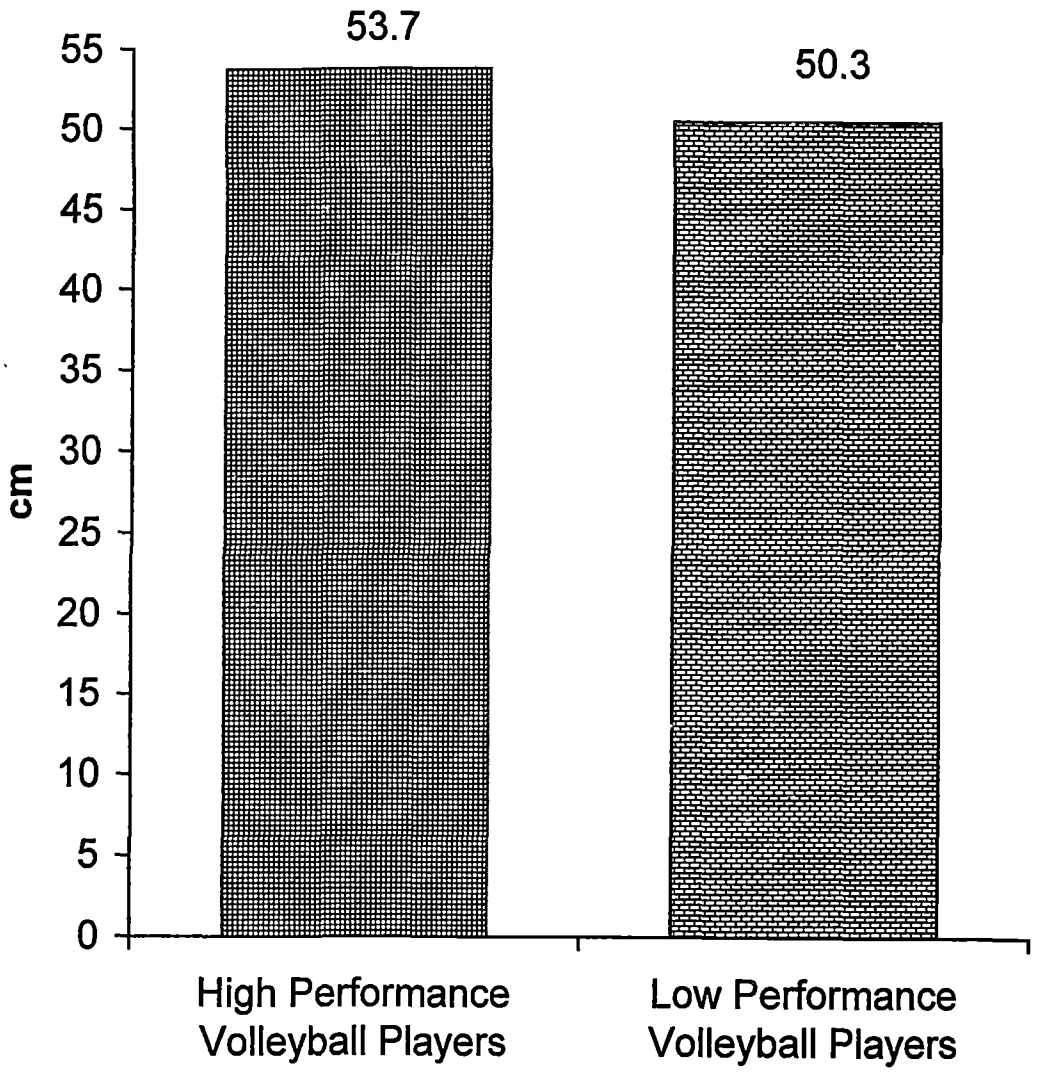

Fig.11: The mean Lower leg length of High and Low performance volleyball players

Table (12) - Biceps muscle girth

Biceps muscle girth in 'Centimeter' of High and Low volleyball players

Biceps muscle girth	High performance volleyball players	Low performance volleyball players
Mean	31.10	29.70
Standard Deviation	1.81	2.12
Obtained value $\|Z\|$	3.59*	
The mean of High performer is > than mean of Low performer $\overline{X}_1 > \overline{X}_2 = 4.71\ \%$		

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 12 Shows significant obtained Z value for one tail test, which leads us to conclude that the mean biceps muscles girth of high performance volleyball players is significantly greater (4.71%), than the mean biceps muscles girth of low performance volleyball players.

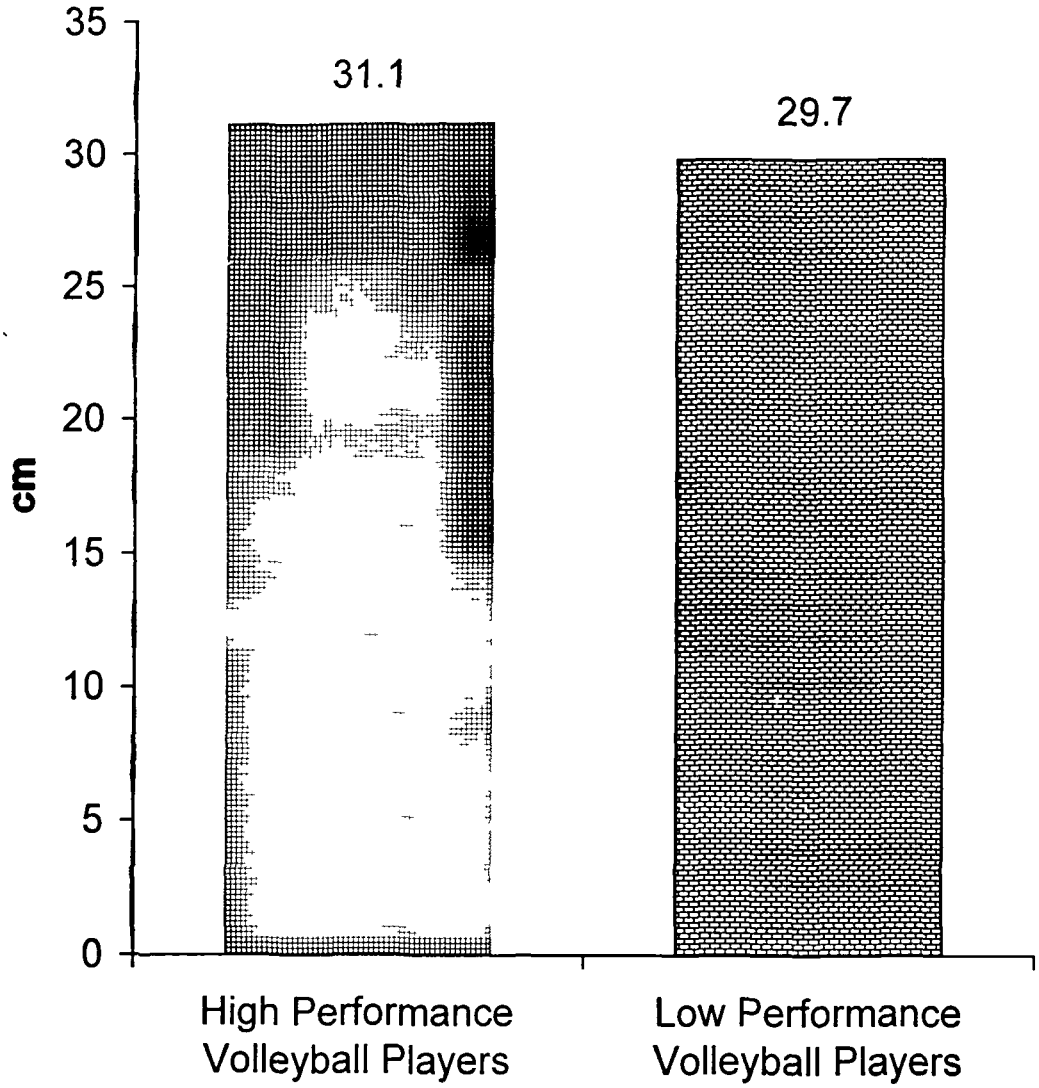

Fig.12: The mean Biceps muscle girth of High and Low performance volleyball players

Table (13) -Calf muscle girth

Calf muscle girth in 'Centimeter' of High and Low performance volleyball players

Calf muscle girth	High performance volleyball players	Low performance volleyball players
Mean	35.84	34.88
Standard Deviation	1.80	1.98
Obtained value $\|Z\|$	2.53*	
The mean of High performer is > than mean of Low performer $\overline{X}_1 > \overline{X}_2 = 2.75\ \%$		

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 13 Shows significant obtained Z value for one tail test, which leads us to conclude that the mean calf muscle girth of high performance volleyball players is significantly greater (2.75%), than the mean calf muscle girth of low performance volleyball players.

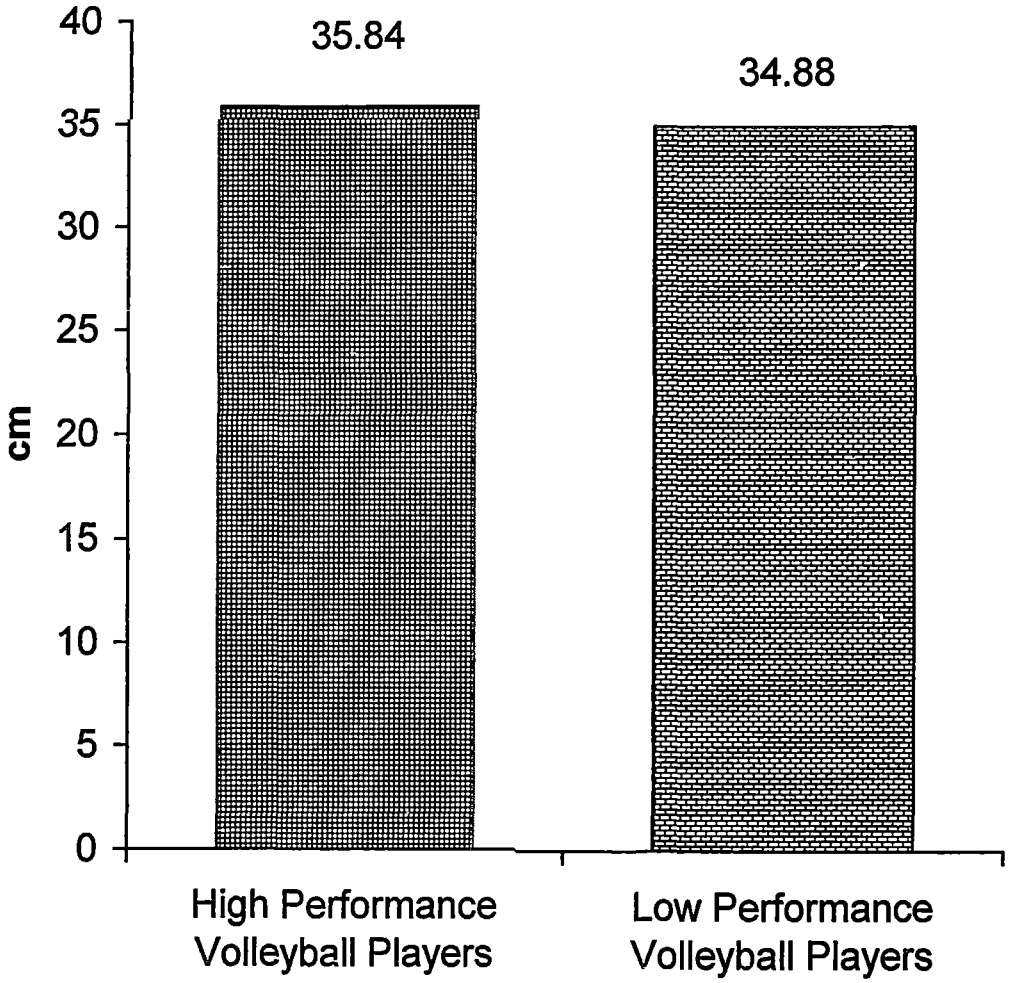

Fig.13: The mean Calf muscle girth of High and Low performance volleyball players

Table (14) - Skin folds

(Biceps, Triceps, Calf, Suprailiac and Sub- Scapular Skin Fold)

Skin folds in 'mm' of High and Low performance volleyball players

Skin folds	High performance volleyball players	Low performance volleyball players
Mean	29.14	33.84
Standard Deviation	6.53	12.90
Obtained value $\|Z\|$	2.30*	
The mean of High performer is < than mean of Low performer $\overline{X}_1 < \overline{X}_2 = 16.13\ \%$		

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 14 Shows significant obtained Z value for one tail test, which leads us to conclude that the mean sum of five skin folds of low performance volleyball players is significantly greater (16.13%), than the mean sum of five skin folds of high performance volleyball players.

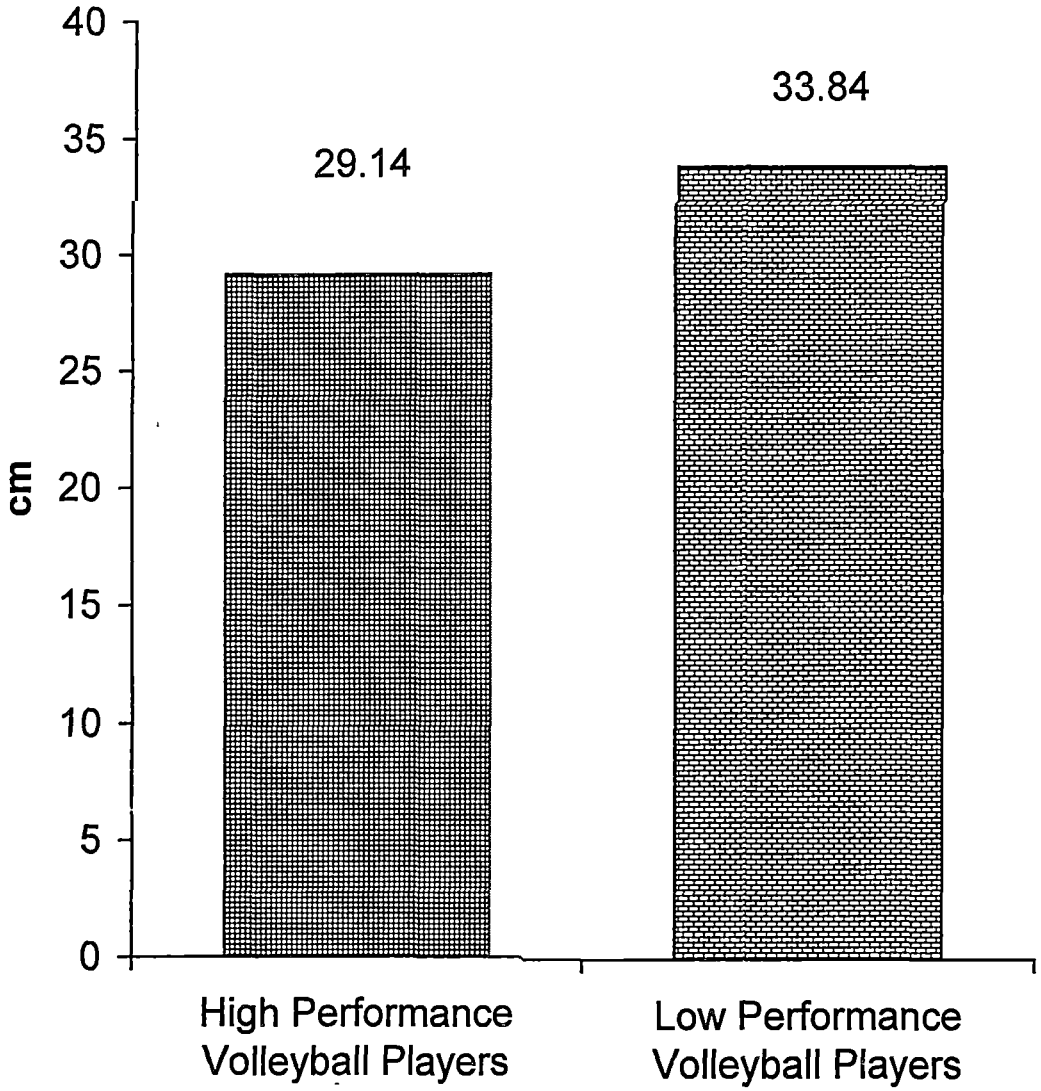

Fig. 14: The mean Skin folds of High and Low performance volleyball players

Table (15) - Wrist width

Wrist width in 'Centimeter' of High and Low performance volleyball players

Wrist width	High performance volleyball players	Low performance volleyball players
Mean	6.28	6.00
Standard Deviation	0.45	0.57
Obtained value $\|Z\|$	2.80*	
The mean of High performer is > than mean of Low performer $\overline{X}_1 > \overline{X}_2 = 4.67\ \%$		

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 15 Shows significant obtained Z value for one tail test, which leads us to conclude that the mean wrist width of high performance volleyball players is significantly greater (4.67%) than the mean wrist width of low performance volleyball players.

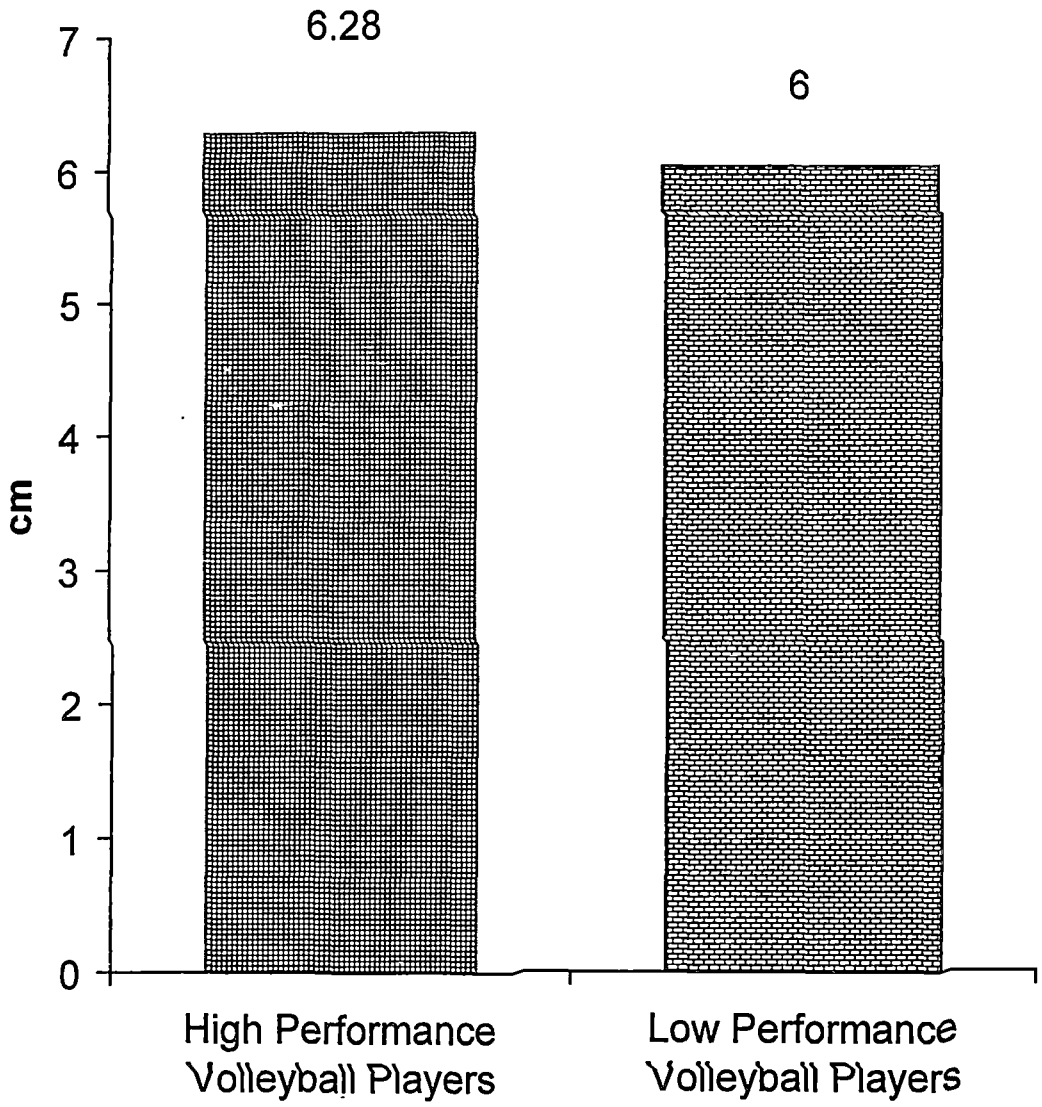

Fig. 15: The mean Wrist width of High and Low performance volleyball players

Table (16) - Hand length *(Palm and Fingers)*

Hand length in 'Centimeter' of High and Low performance volleyball players

Hand length	High performance volleyball players	Low performance volleyball players
Mean	21.74	20.50
Standard Deviation	0.99	1.04
Obtained value $\|Z\|$	6.20*	
The mean of High performer is > than mean of Low performer $\overline{X}_1 > \overline{X}_2 = 6.05\ \%$		

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 16 Shows significant obtained Z value for one tail test, which leads us to conclude that the mean hand length of high performance volleyball players is significantly greater (6.05%), then the mean hand length of low performance volleyball players.

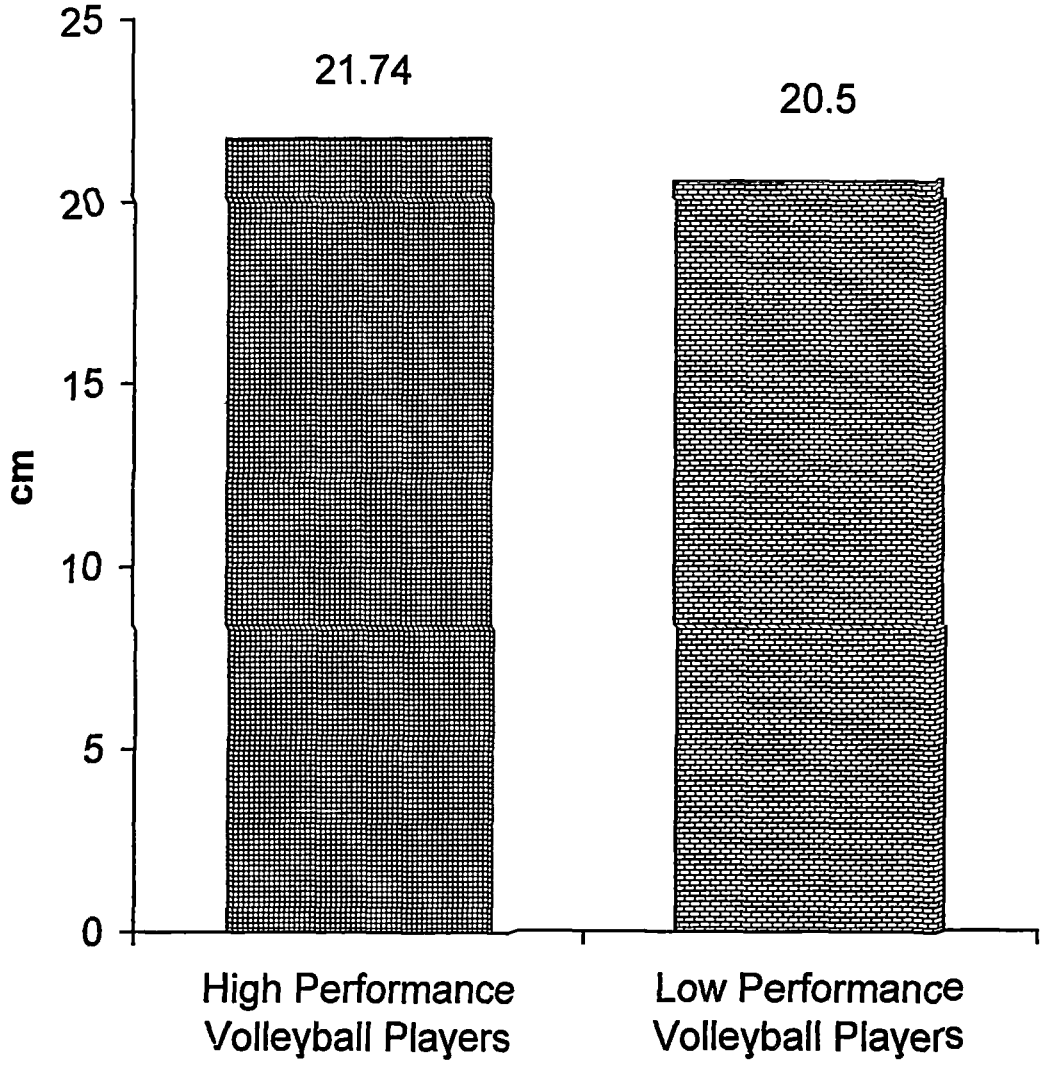

Fig. 16: The mean Hand length *(palm and fingers)* of High and Low performance volleyball players

Table (17) - Heart rate

Heart rate in 'beats/min.' of High and Low performance volleyball players

Heart rate	High performance volleyball players	Low performance volleyball players
Mean	54.44	67.00
Standard Deviation	4.33	5.66
Obtained value $\|Z\|$	2.56*	
The mean of High performer is < than mean of Low performer $\overline{X}_1 < \overline{X}_2 = 3.97\ \%$		

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 17 Shows significant obtained Z value for one tail test, which leads us to conclude that the mean heart rate of high performance volleyball players is significantly lesser (3.97%), than the mean heart rate of low performance volleyball players.

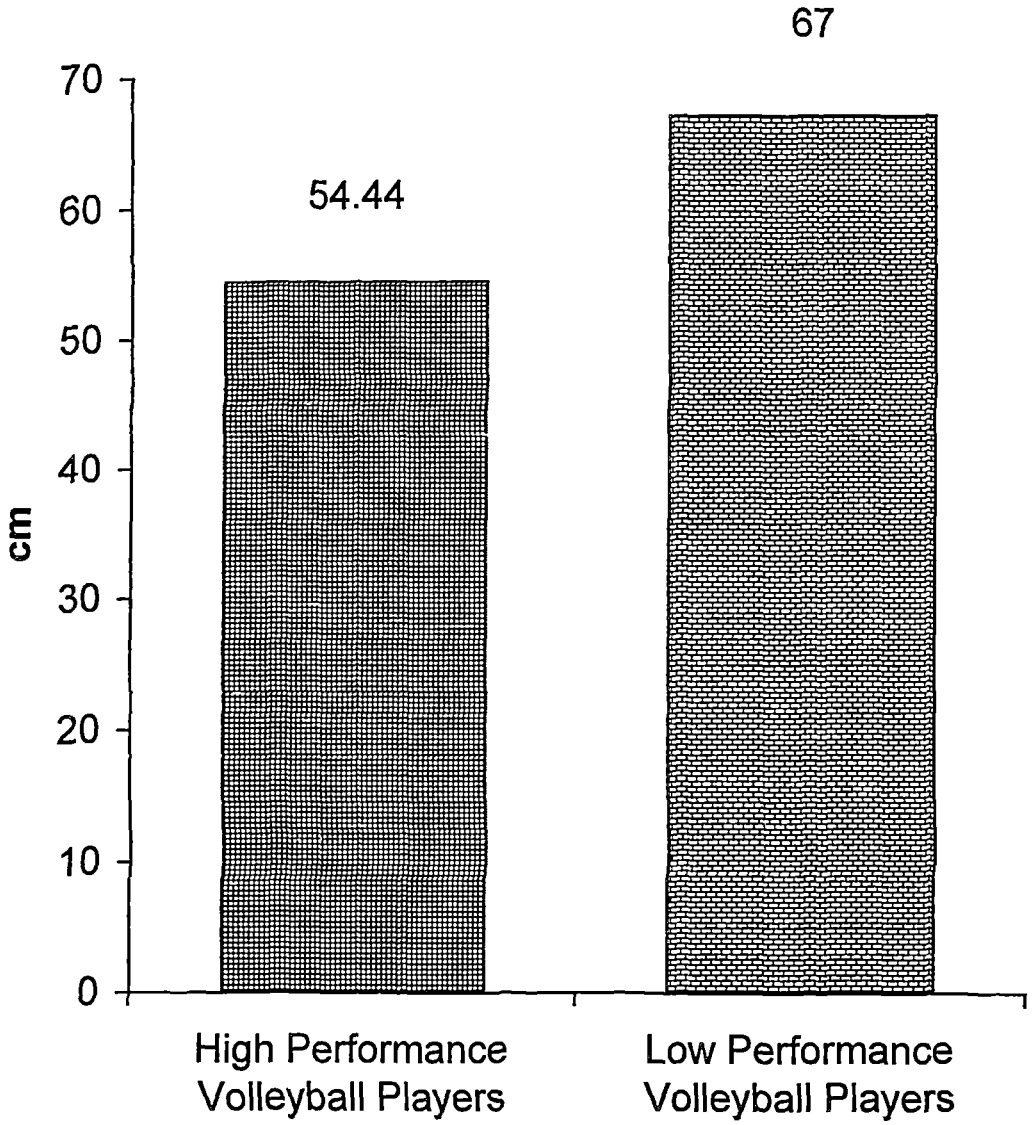

Fig. 17: The mean Heart rate of High and Low performance volleyball players

Table 18 (A) - Blood pressure *(Systolic & Diastolic)*

Blood pressure *(systolic)* in 'mm/Hg' of High and Low performance volleyball players

Blood pressure (systolic)	High performance volleyball players	Low performance volleyball players
Mean	121.60	124.30
Standard Deviation	7.58	11.24
Obtained value $\|Z\|$	1.41	

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 18(A) Shows insignificant obtained Z value for one tail test, which leads us to conclude that the significant difference does not exist between the systolic blood pressure of high and low performance volleyball players.

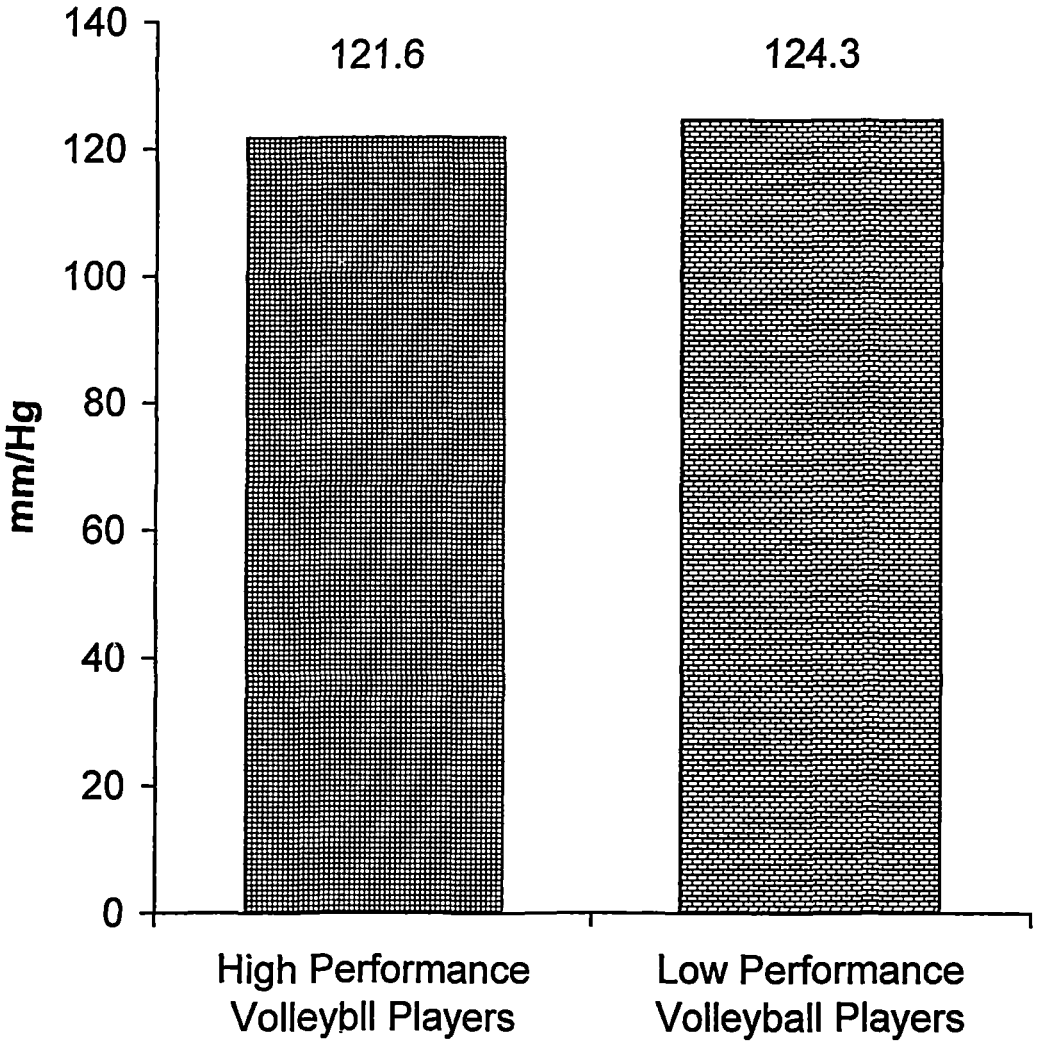

Fig. 18-A: The mean Blood pressure *(Systolic)* of High and Low performance volleyball Players

Table 18 (B) - Blood pressure (*Diastolic*)

Blood pressure *(Diastolic)* in 'mm/Hg' of High and Low performance volleyball players

Blood pressure (Diastolic)	High performance volleyball players	Low performance volleyball players
Mean	80.30	82.60
Standard Deviation	7.24	8.90
Obtained value $\|Z\|$	1.42	

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 18(B) Shows insignificant obtained Z value for one tail test, which leads us to conclude that significant difference does not exist between the (diastolic) blood pressure of high and low performance volleyball players.

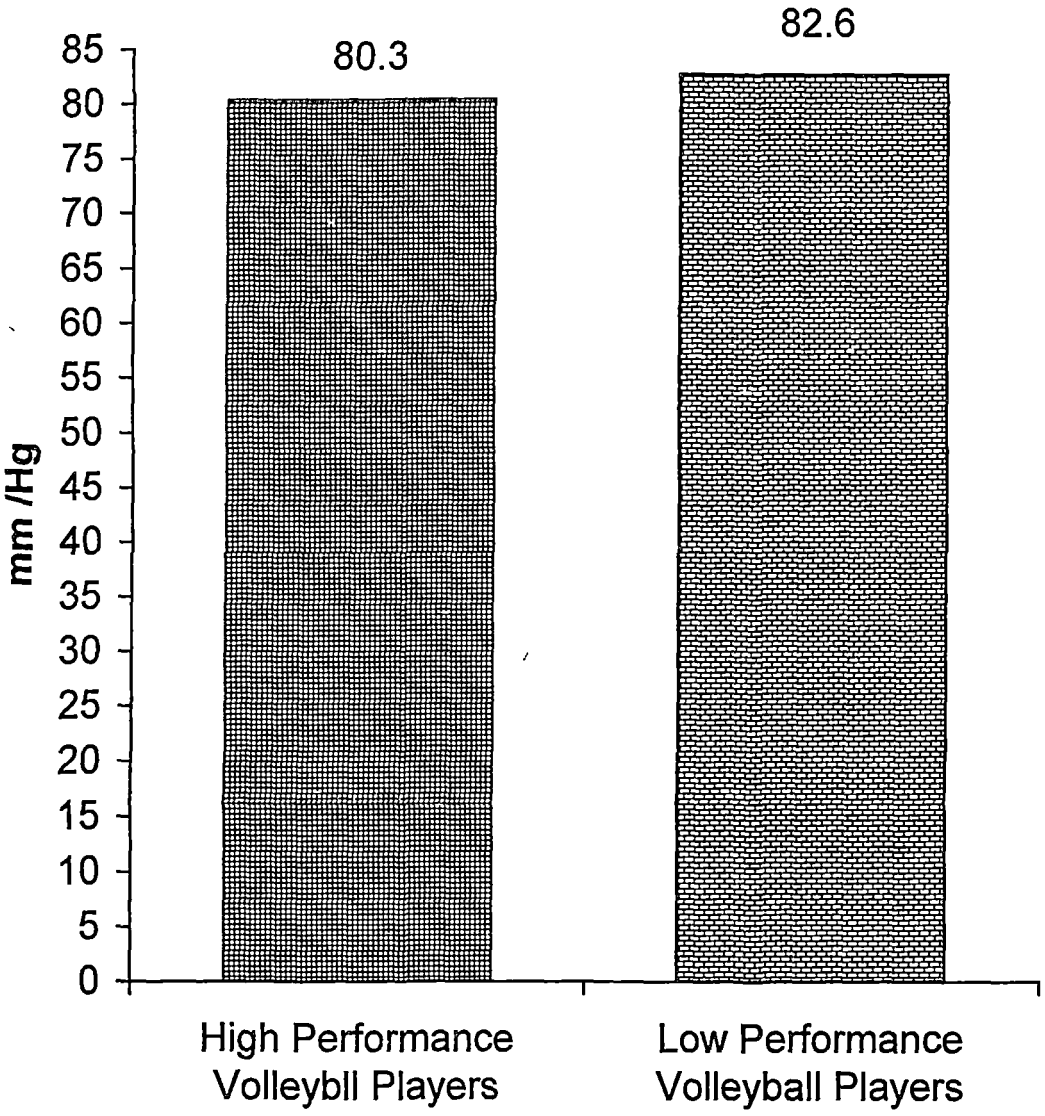

Fig. 18-B : The mean Blood pressure *(Diastolic)* of High and Low performance volleyball players

Table (19) - Vital capacity

Vital capacity in 'CC' of High and Low performance volleyball players

Vital capacity	High performance volleyball players	Low performance volleyball players
Mean	6378	5916
Standard Deviation	541.21	442.42
Obtained value $\|Z\|$	4.67*	
The mean High performer is > then mean Low performer $\overline{X}_1 > \overline{X}_2 = 7.81\%$		

* *Significant at 0.05 level*

** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 19 Shows significant obtained Z value for one tail test, which leads us to conclude that the mean vital capacity of high performance volleyball players is significantly greater (7.81%), than the mean vital capacity of low performance volleyball players.

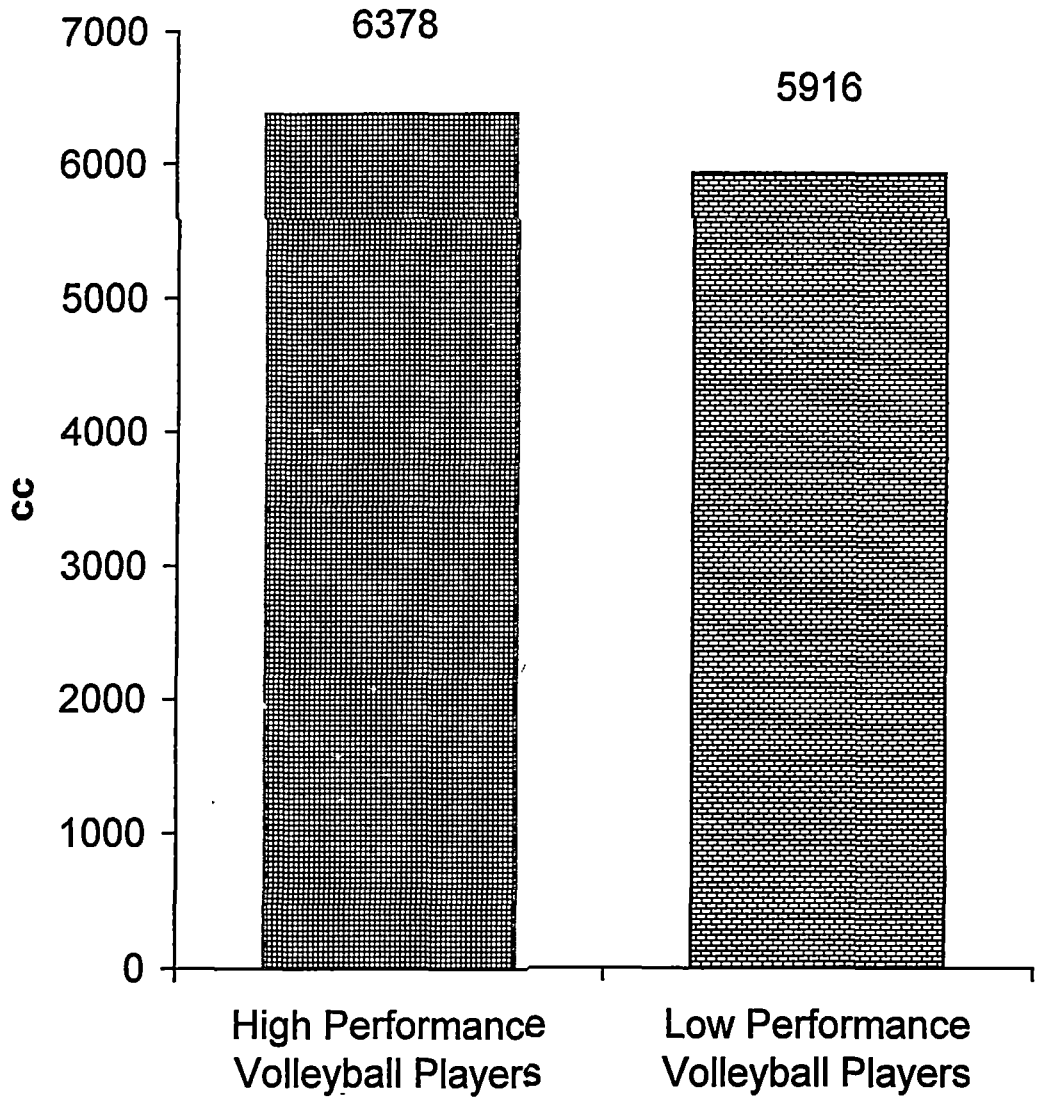

Fig. 19: The mean Vital capacity of High and Low performance volleyball players

Table (20) - Total arm length

Total arm length in 'Centimeter' of High and Low performance volleyball players

Total arm length	High performance volleyball players	Low performance volleyball players
Mean	85.70	78.18
Standard Deviation	4.61	4.39
Obtained value $\|Z\|$	8.26*	
The mean of High performer is > than mean of Low performer $\overline{X}_1 > \overline{X}_2 = 9.62\%$		

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 20 Shows significant obtained Z value for one tail test, which leads us to conclude that the mean total arm length of high performance volleyball players is significantly greater (9.62%), than the mean total arm length of low performance volleyball players.

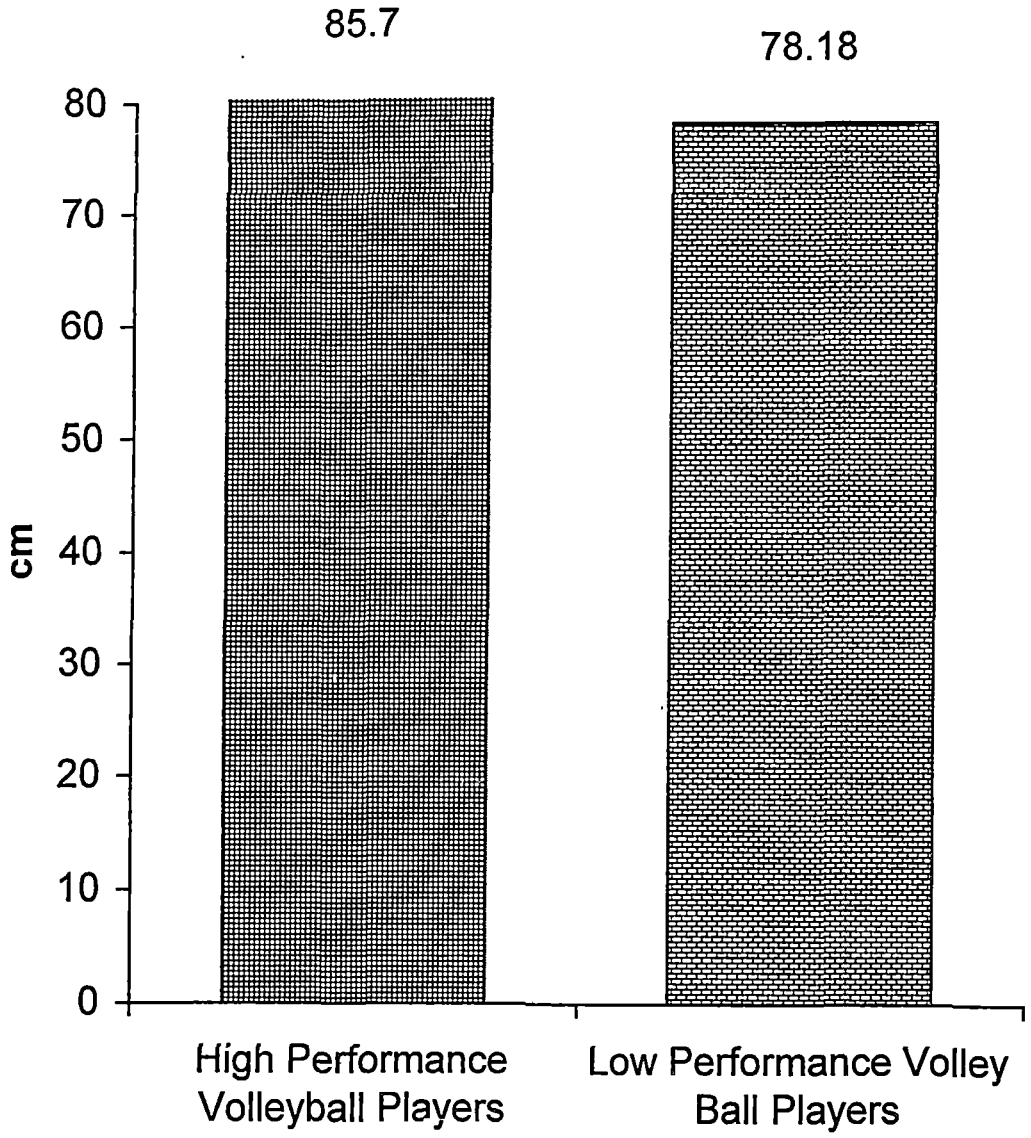

Fig. 20 : The mean Total arm length of High and Low performance volleyball players

Table (21) - Endomorphic rating

Endomorphic rating of High and Low performance volleyball players

Endomorphic rating	High performance volleyball players	Low performance volleyball players
Mean	1.66	2.06
Standard Deviation	0.51	0.98
Obtained value $\|Z\|$	2.54*	
The mean of High performer is < than mean of Low performer $\overline{X}_1 < \overline{X}_2 =$ 24.09%		

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 21 Shows significant obtained Z-value for one tail test, which leads us to conclude that the mean endomorphic rating of low performance volleyball players is significantly greater (24.09%) than the mean endomorphic ratings of high performance volleyball players.

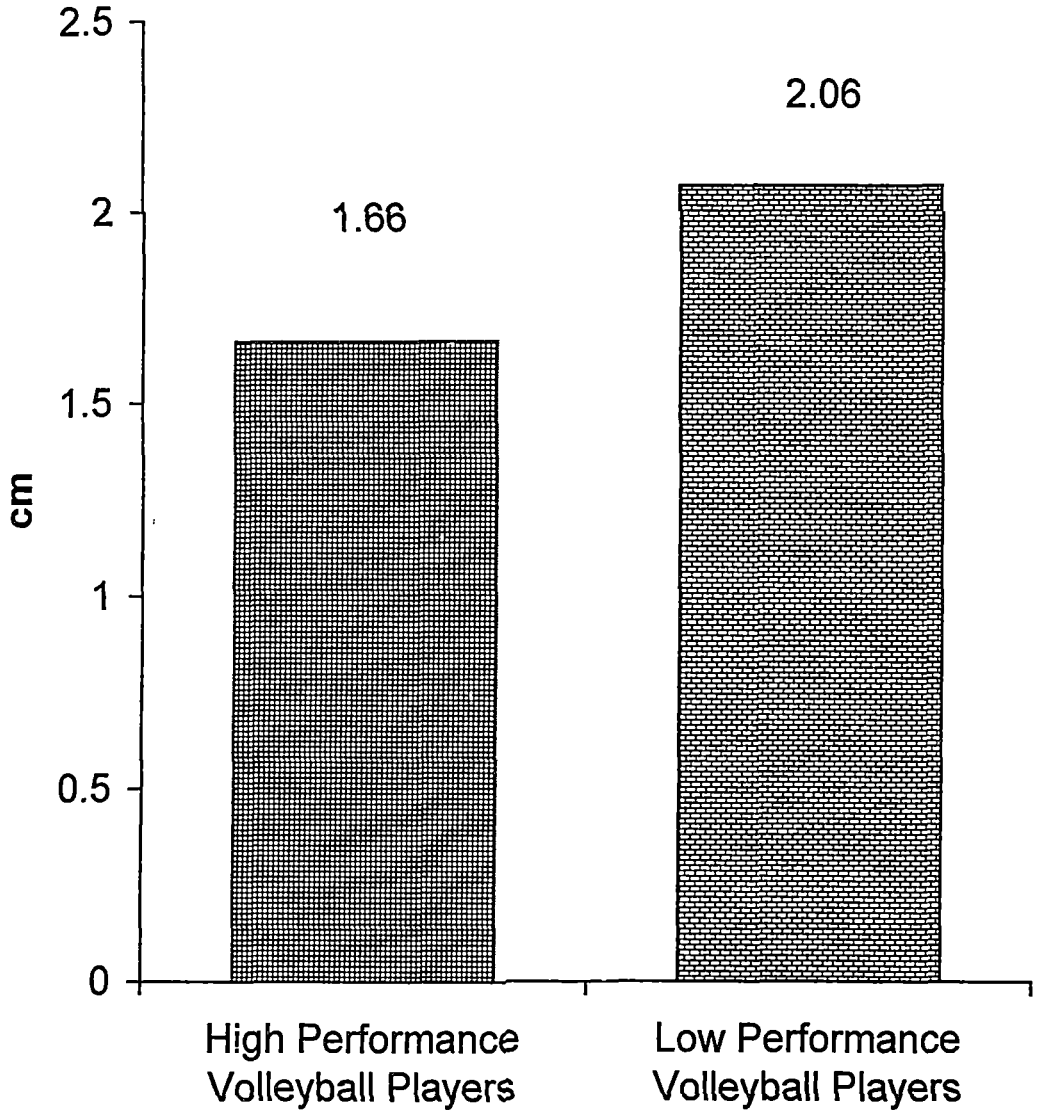

Fig. 21: The mean Endomorphic rating of High and Low performance volleyball players

Table (22) - Mesomorphic rating

Mesomorphic ratings of High and Low performance volleyball players

Mesomorphic rating	High performance volleyball players	Low performance volleyball players
Mean	2.27	2.04
Standard Deviation	1.01	0.91
Obtained value $\|Z\|$	1.20	

* *Significant at 0.05 level*

** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 22 Shows insignificant obtained Z-value for one tail test, which leads us to conclude that the mean mesomorphic rating of high performance volleyball players is not significantly greater than the mean mesomorphic rating of low performance volleyball players.

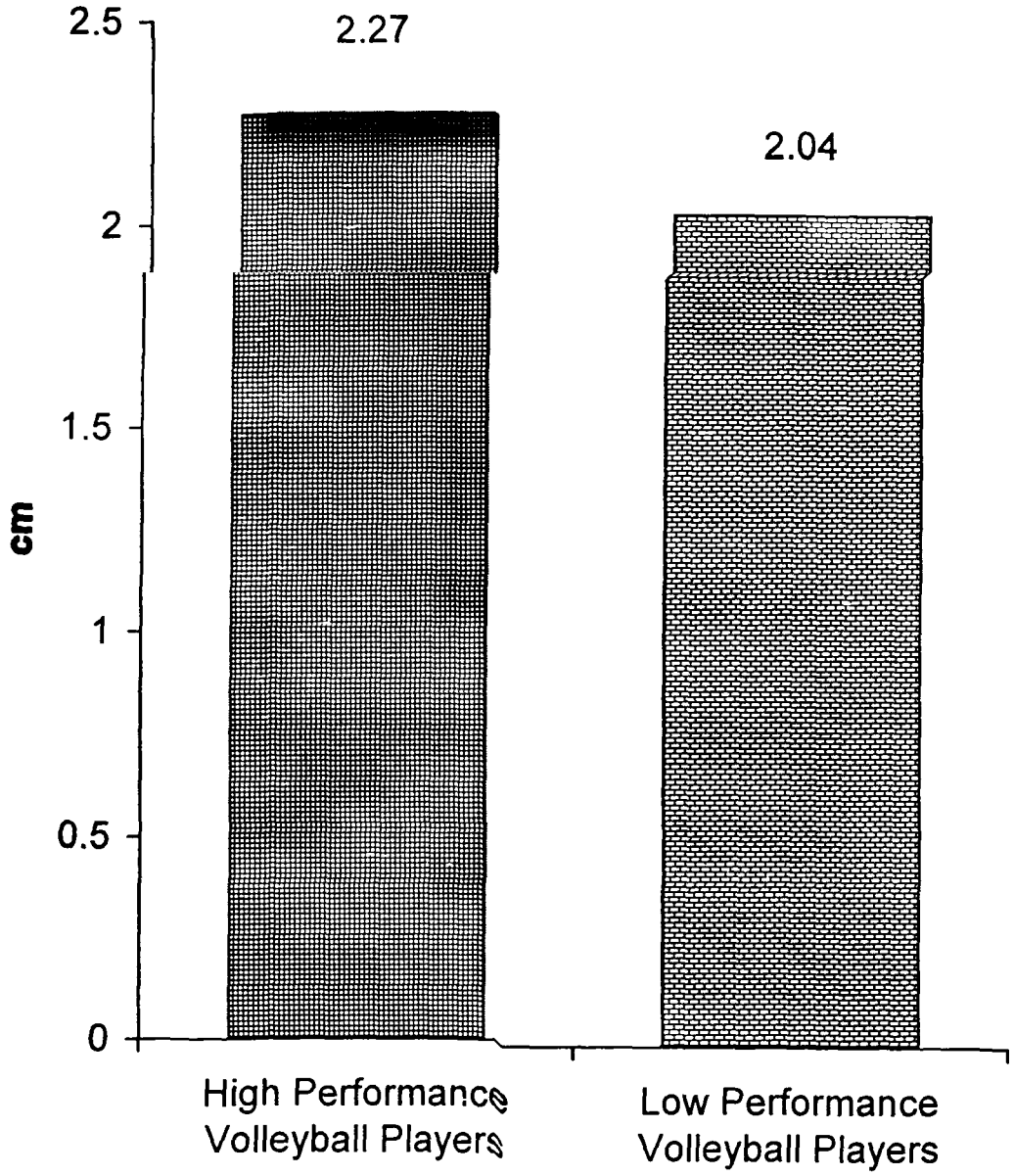

Fig. 22: The mean Mesomorphic rating of High and Low performance volleyball players

Table (23) - Ectomorphic ratings

Ectomorphic ratings in of High and Low performance volleyball players

Ectomorphic rating	High performance volleyball players	Low performance volleyball players
Mean	4.22	3.81
Standard Deviation	1.06	1.05
Obtained value $\|Z\|$	1.94*	
The mean of High performer is > than mean of Low performer $\overline{X}_1 > \overline{X}_2 = 10.76\%$		

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 23 Shows significant obtained Z-value for one tail test, which leads us to conclude that the mean ectomorphic ratings of high performance volleyball players is significantly greater (10.76 %) than the mean ectomorphic ratings of low performance volleyball players.

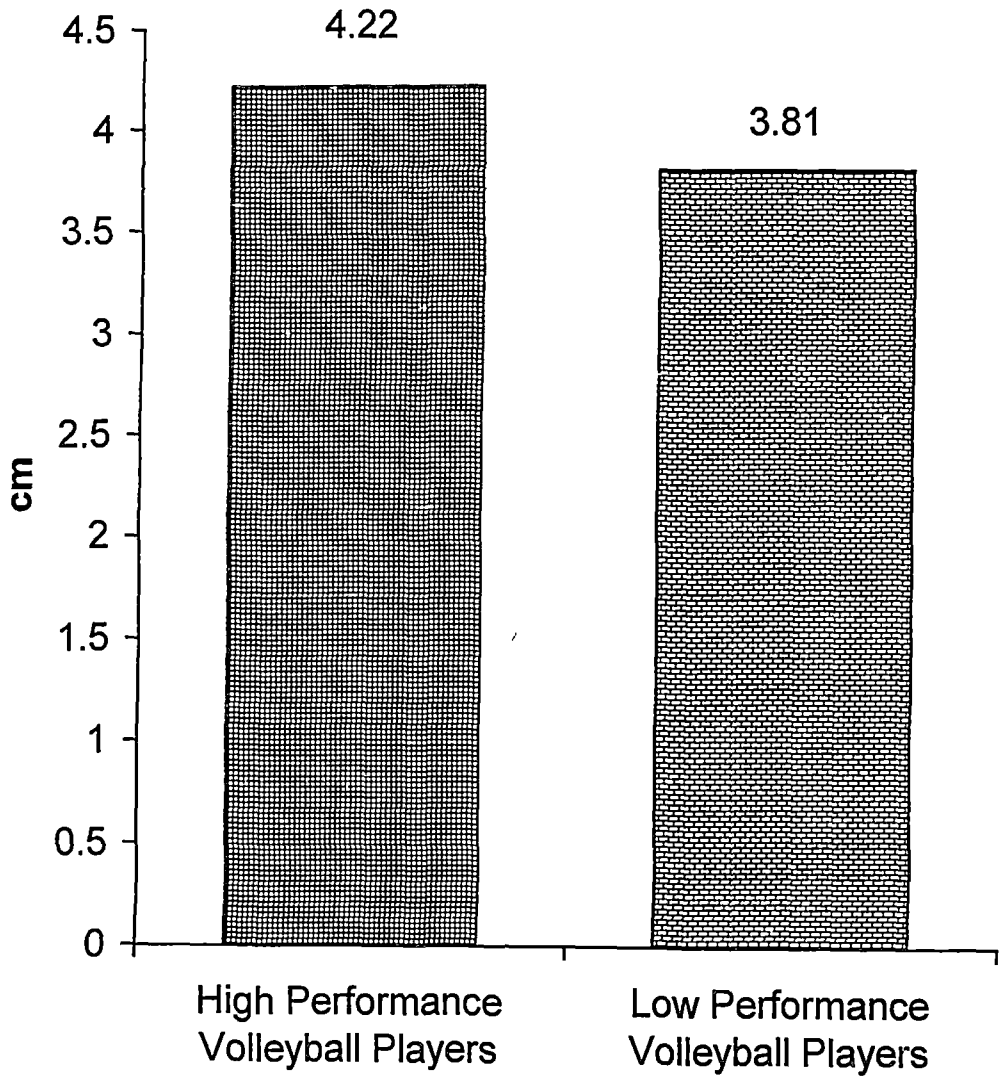

Fig. 23: The mean Ectomorphic rating of High and Low performance volleyball players

Table (24) - Thigh length – Lower leg length index

Thigh length – Lower leg length index of High and Low performance volleyball players

Thigh length-Lower leg length index	High performance volleyball players	Low performance volleyball players
Mean	90.4	89.79
Standard Deviation	6.009	6.67
Obtained value $\|Z\|$	0.20	

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 24 Shows insignificant obtained Z-value for one tail test, which leads us to conclude that the mean thigh length – lower leg length index of high performance volleyball players is not significantly greater than the mean thigh length – lower leg length index of low performance volleyball players.

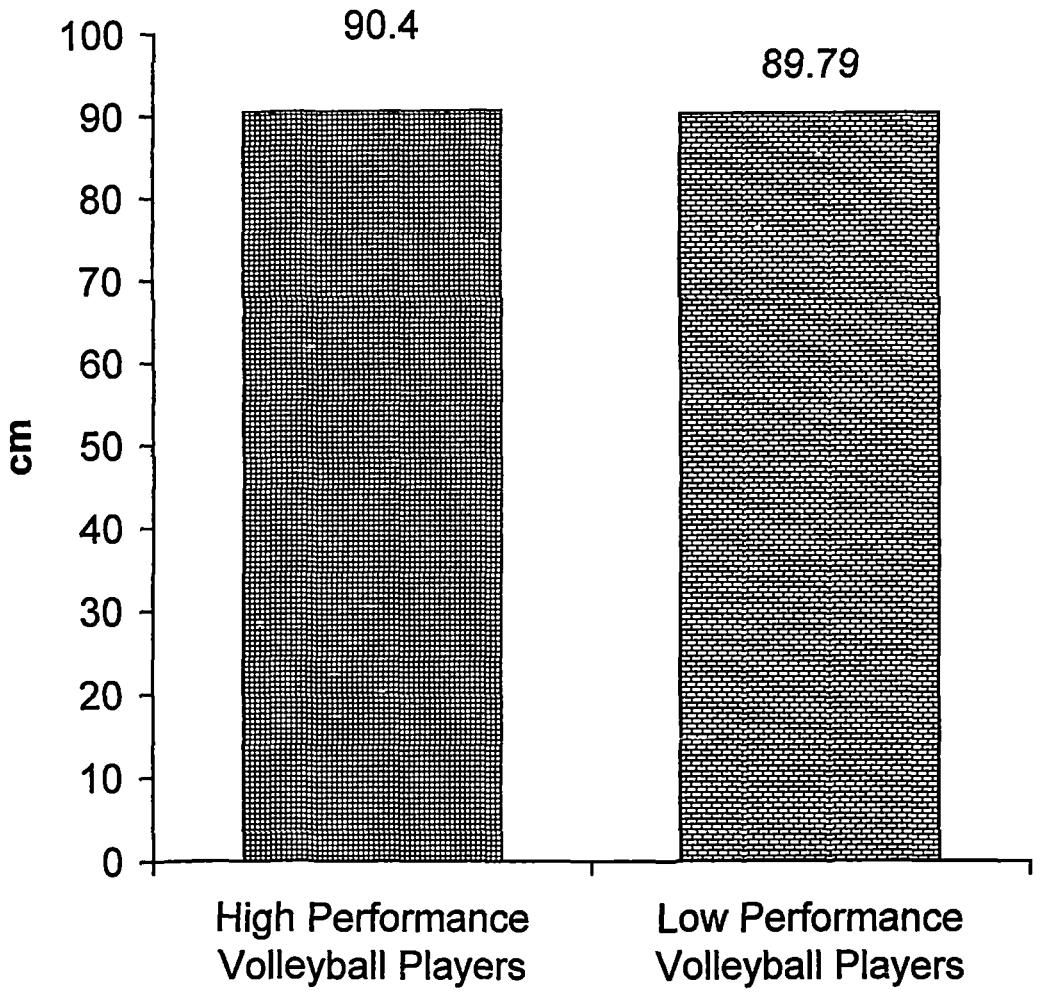

Fig. 24: The mean Thigh length – Lower leg length index of High and Low performance volleyball players

Table (25) - Sitting height – Stature index

Sitting height-Stature index of High and Low performance volleyball players

Sitting height-Stature index	High performance volleyball players	Low performance volleyball players
Mean	49.66	50.00
Standard Deviation	1.60	1.42
Obtained value $\|Z\|$	1.85*	
The mean of High performer is < than mean of Low performer $\overline{X}_1 < \overline{X}_2 =$ 10.75%		

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 25 Shows significant obtained Z-value for one tail test, which leads us to conclude that the mean sitting height-stature index of low performance volleyball players is significantly (10.75%) greater than the mean sitting height-stature index of high performance volleyball players.

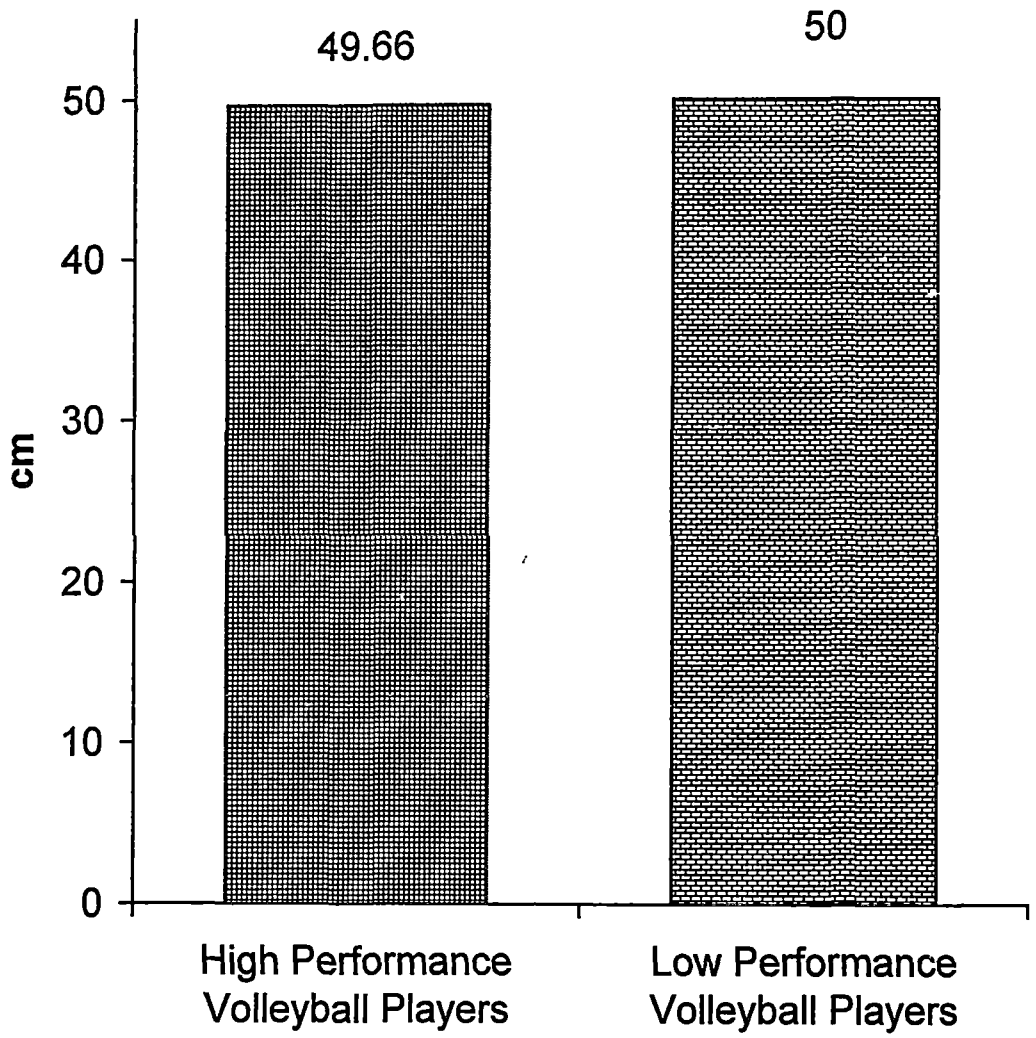

Fig. 25: The mean Sitting height – Stature index of High and Low performance volleyball players

Table (26) - Lower arm length – Upper arm length index

Lower arm length – Upper arm length index of High and Low performance volleyball players

Lower arm length-Upper arm length index	High performance volleyball players	Low performance volleyball players
Mean	81.86	83.10
Standard Deviation	4.89	7.30
Obtained value $\|Z\|$	0.998	

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 26 Shows insignificant obtained Z-value for one tail test, which leads us to conclude that the mean lower arm length – upper arm length index of high performance volleyball players are not significantly greater than the mean lower arm length – upper arm length index of low performance volleyball players.

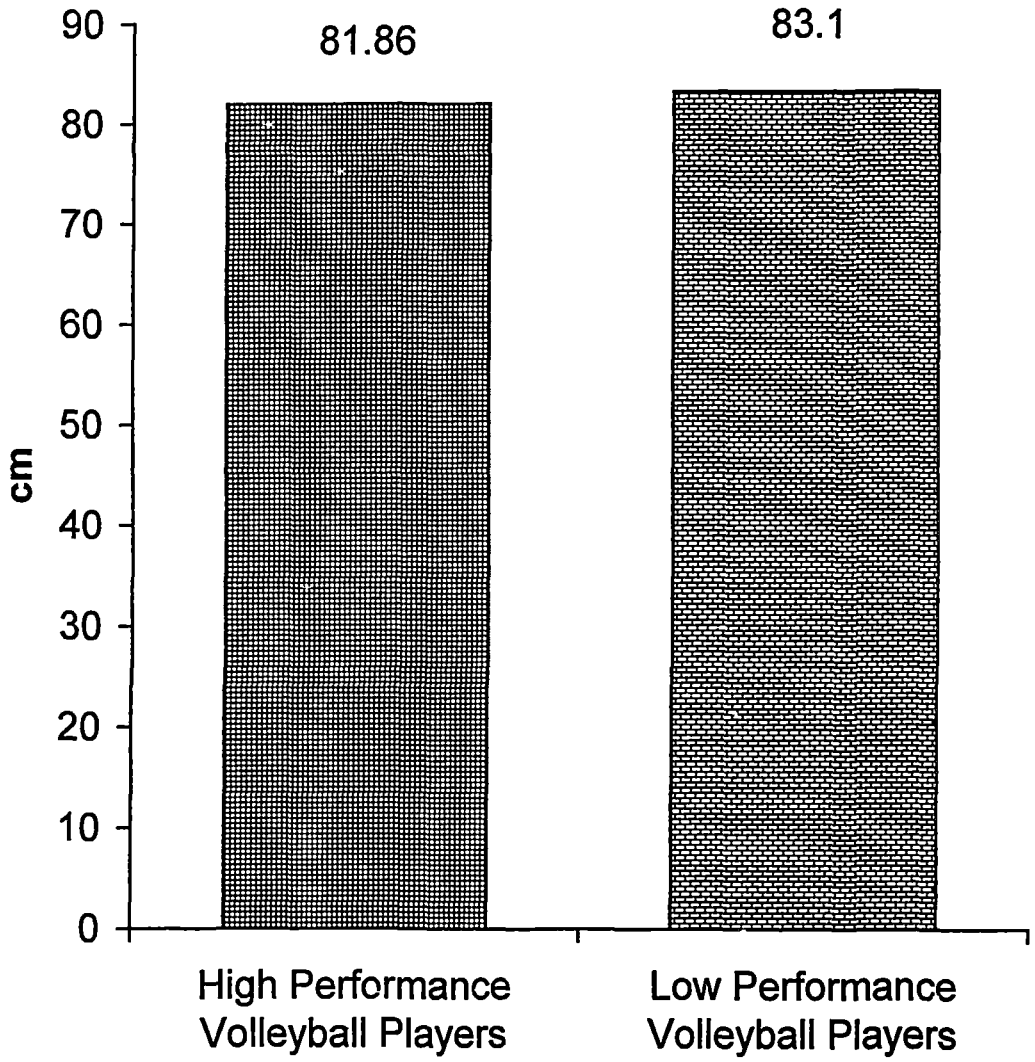

Fig. 26: The mean Lower arm length – Upper arm length index of High and Low performance volleyball players

Table (27) - Hip width – Stature index

Hip width – Stature index of High and Low performance volleyball players

Hip width-Stature index	High performance volleyball players	Low performance volleyball players
Mean	15.36	15.37
Standard Deviation	0.65	0.61
Obtained value $\|Z\|$	0.08	

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 27 Shows insignificant obtained Z-value for one tail test, which leads us to conclude that the mean hip width – stature index of high performance volleyball players is not significantly greater than the mean hip width – stature index of low performance volleyball players.

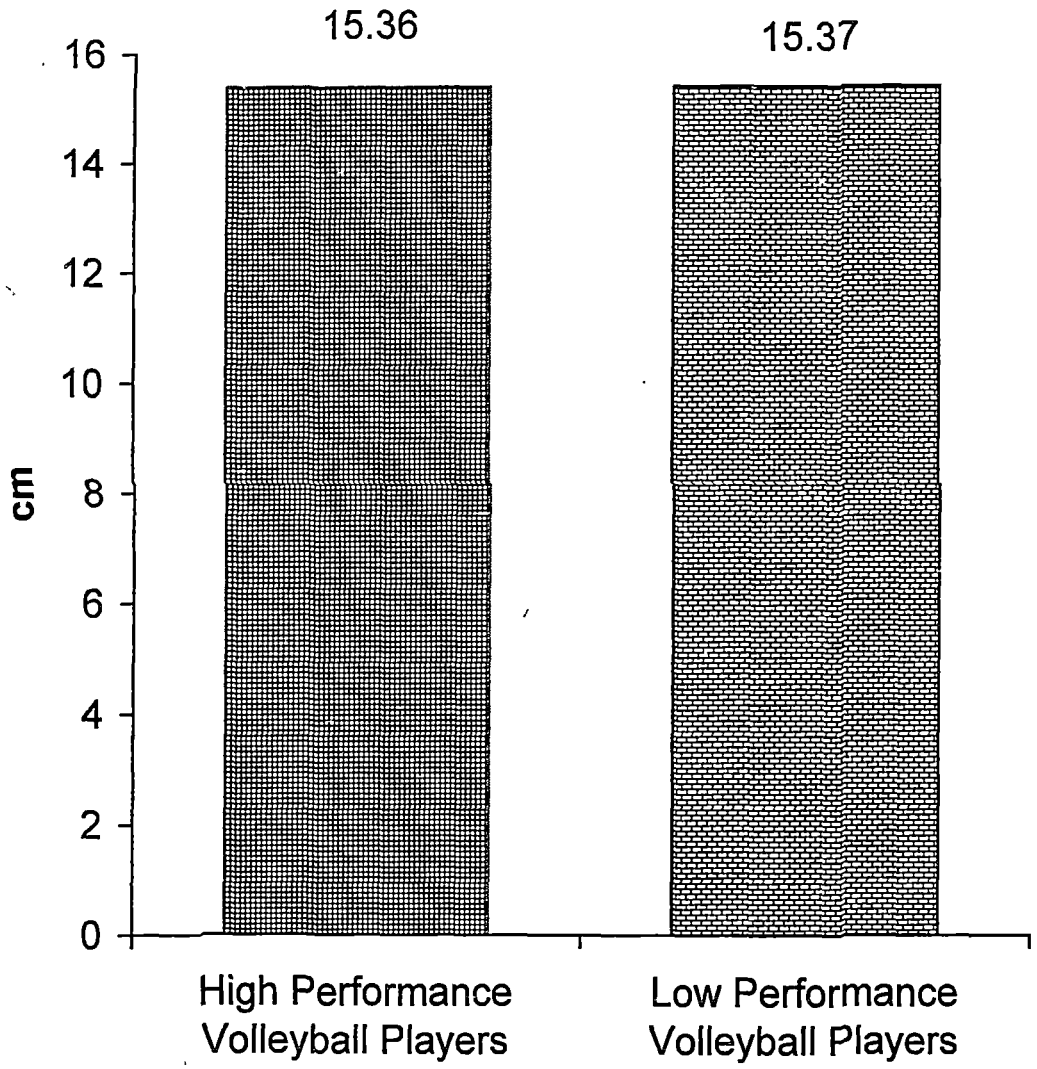

Fig. 27: The mean Hip width – Stature index of High and Low performance volleyball players

Table (28) - Shoulder width – Stature index

Shoulder width – Stature index of High and Low performance volleyball players

Shoulder width-Stature index	High performance volleyball players	Low performance volleyball players
Mean	22.29	22.20
Standard Deviation	0.88	1.70
Obtained value $\|Z\|$	0.33	

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 28 Shows insignificant obtained Z-value for one tail test, which leads us to conclude that the mean shoulder width – stature index of high performance volleyball players is not significantly greater than the mean shoulder width – stature index of low performance volleyball players.

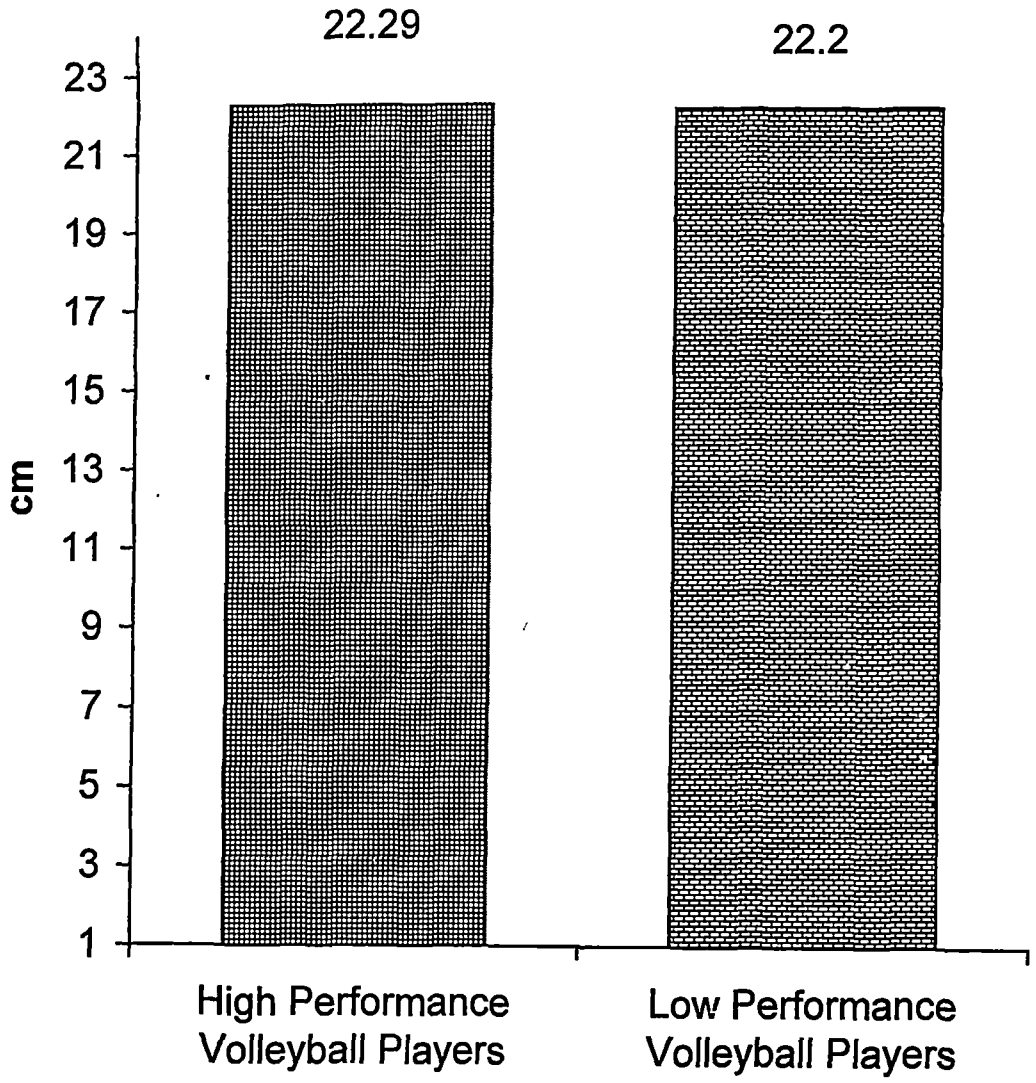

Fig. 28: The mean Shoulder width – Stature index of high and low performance volleyball players

Table (29) - Ponderal index

Ponderal index of High and Low performance volleyball players

Ponderal index	High performance volleyball players	Low performance volleyball players
Mean	43.93	44.23
Standard Deviation	1.69	1.40
Obtained value $\|Z\|$	0.97	

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 29 Shows insignificant obtained Z-value for one tail test, which leads us to conclude that the mean ponderal index of high performance volleyball players is significantly lesser than the mean ponderal index of low performance volleyball players.

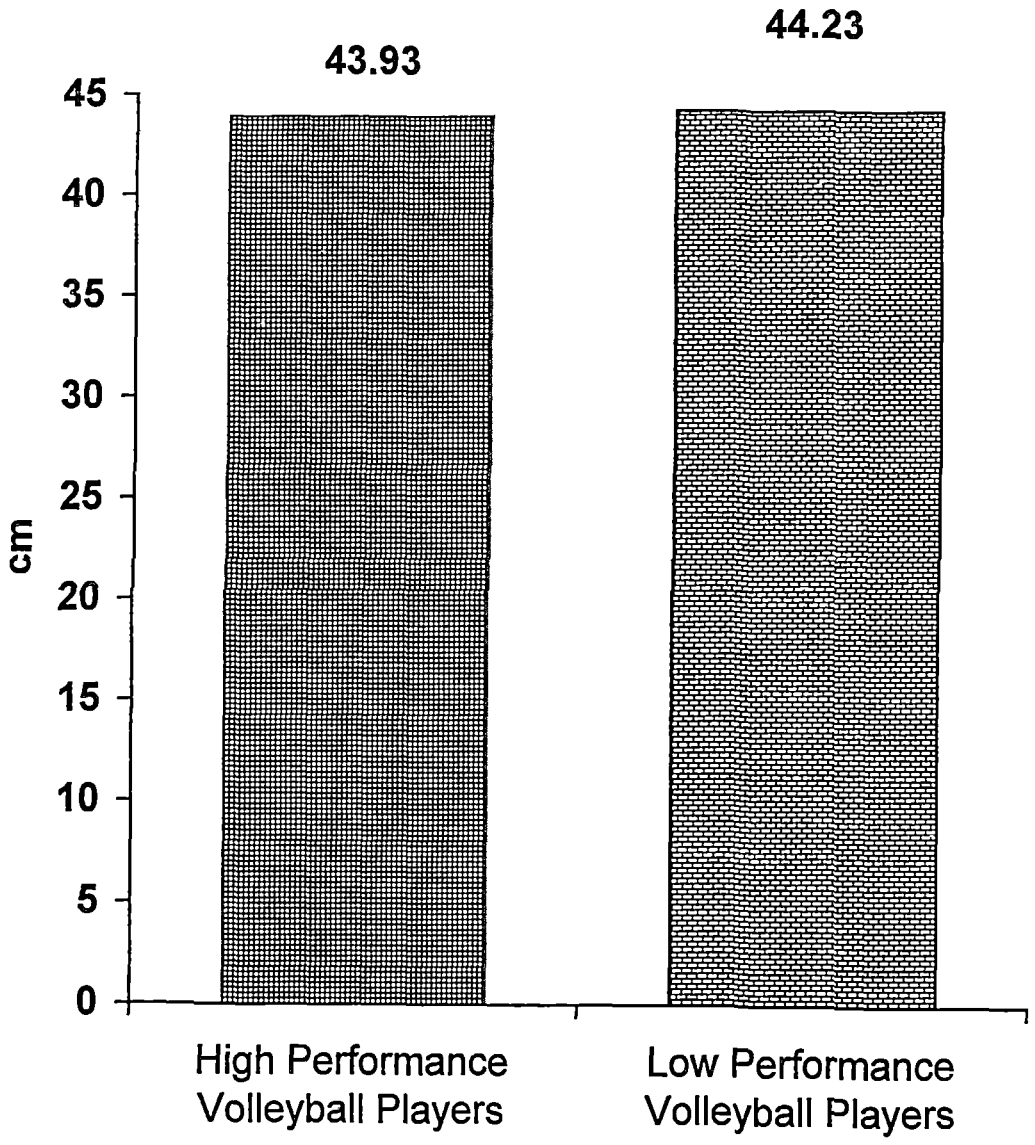

Fig. 29: The mean Ponderal index of high and low performance volleyball players

Table (30) – Total arm length – Hand length index

Total arm length – Hand length index of High and Low performance volleyball players

Total arm length – Hand length index	High performance volleyball players	Low performance volleyball players
Mean	25.40	26.23
Standard Deviation	1.06	1.57
Obtained value $\|Z\|$	3.095*	
The mean of High performer is < than mean of Low performer $\overline{X}_1 < \overline{X}_2 =$ 3.27%		

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 30 Shows significant obtained Z-value for one tail test, which leads us to conclude that the mean total arm length – hand length index of low performance volleyball players is significantly greater (3.27%) than the mean total arm length – hand length index of high performance volleyball players.

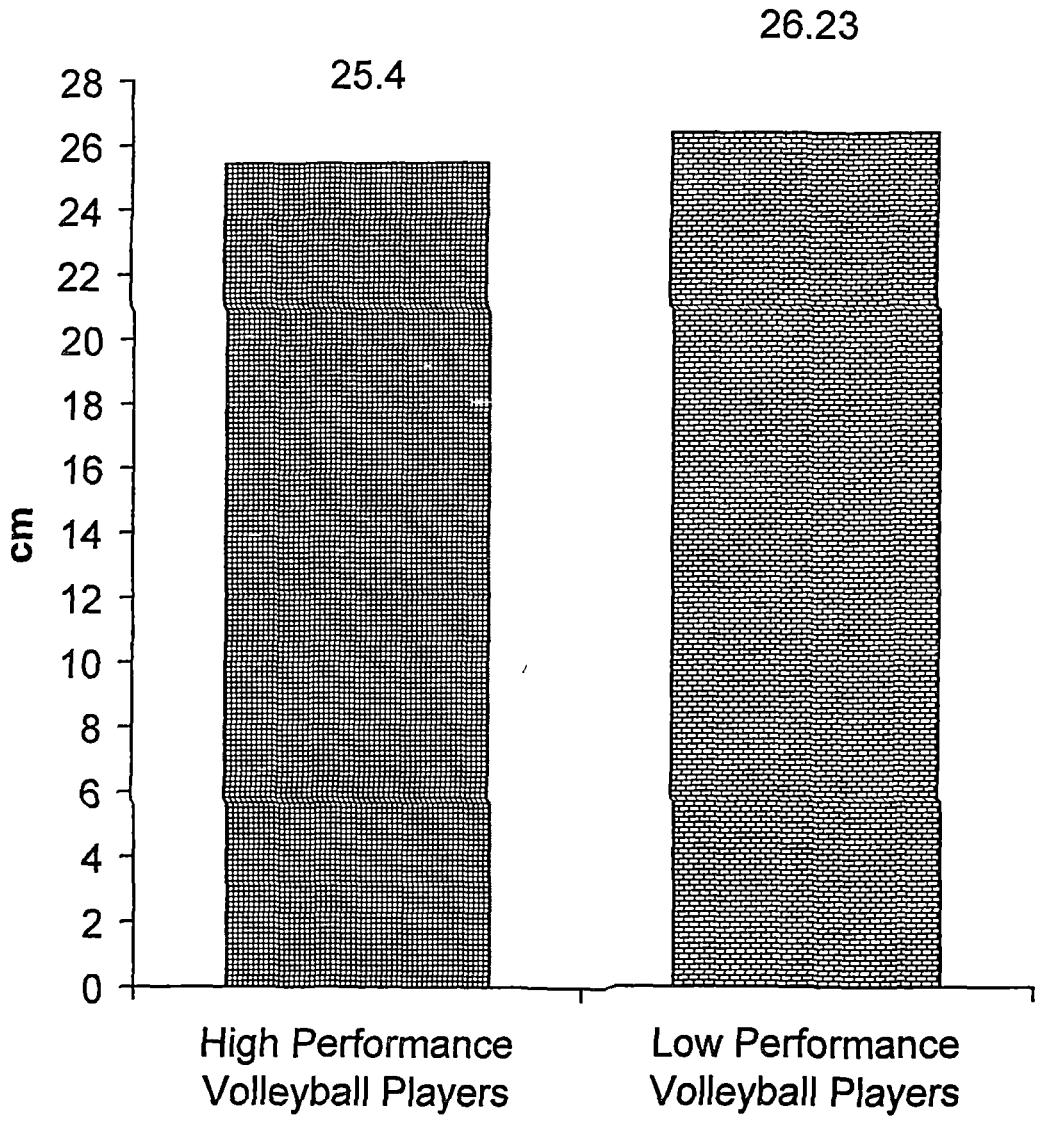

Fig. 30: The mean Total arm length – Hand length index of high and low performance volleyball players

Table (31) - Total arm length – Lower arm length index

Total arm length – Lower arm length index of High and Low performance volleyball players

Total arm length – Lower arm length index	High performance volleyball players	Low performance volleyball players
Mean	34.18	35.14
Standard Deviation	1.84	1.92
Obtained value $\|Z\|$	2.55*	
The mean of High performer is < than mean of Low performer $\overline{X}_1 < \overline{X}_2 = 2.81\%$		

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 31 Shows significant obtained Z-value for one tail test, which leads us to conclude that the mean total arm length – lower arm length index of low performance volleyball players is significantly greater (2.81%) than the mean total arm length – lower arm length index of high performance volleyball players.

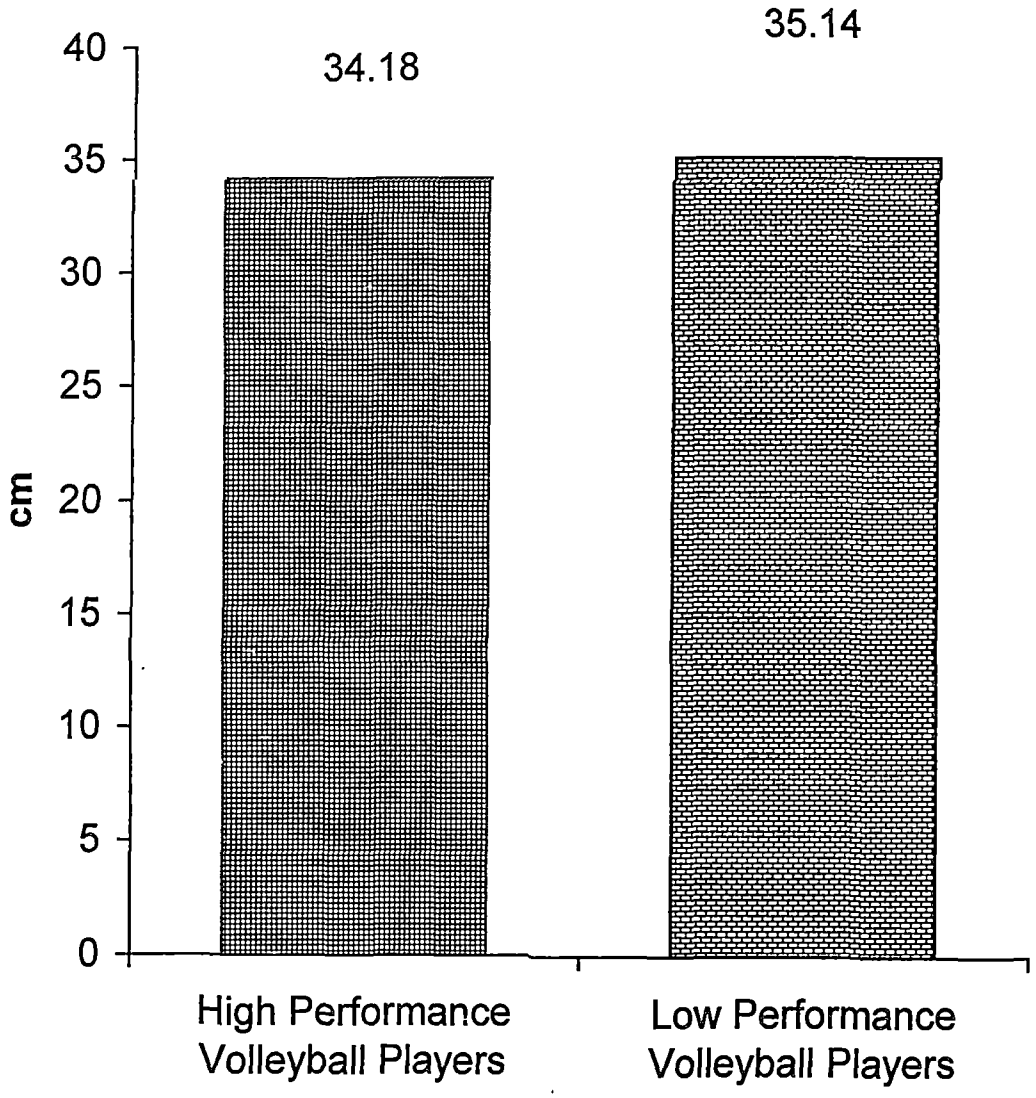

Fig. 31: The mean Total arm length – Lower arm length index of high and low performance volleyball players

Table (32) - Total arm length – Upper arm length index

Total arm length – Upper arm length index of high and low performance volleyball players

Total arm length – Upper arm length index	High performance volleyball players	Low performance volleyball players
Mean	41.78	43.32
Standard Deviation	2.64	3.08
Obtained value $\|Z\|$	2.66*	
The mean of High performer is < than mean of Low performer $\overline{X}_1 < \overline{X}_2 =$ 3.69%		

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 32 Shows significant obtained Z-value for one tail test, which leads us to conclude that the mean total arm length – upper arm length index of low performance volleyball players is significantly greater (3.69%) than the mean total arm length – upper arm length index of high performance volleyball players.

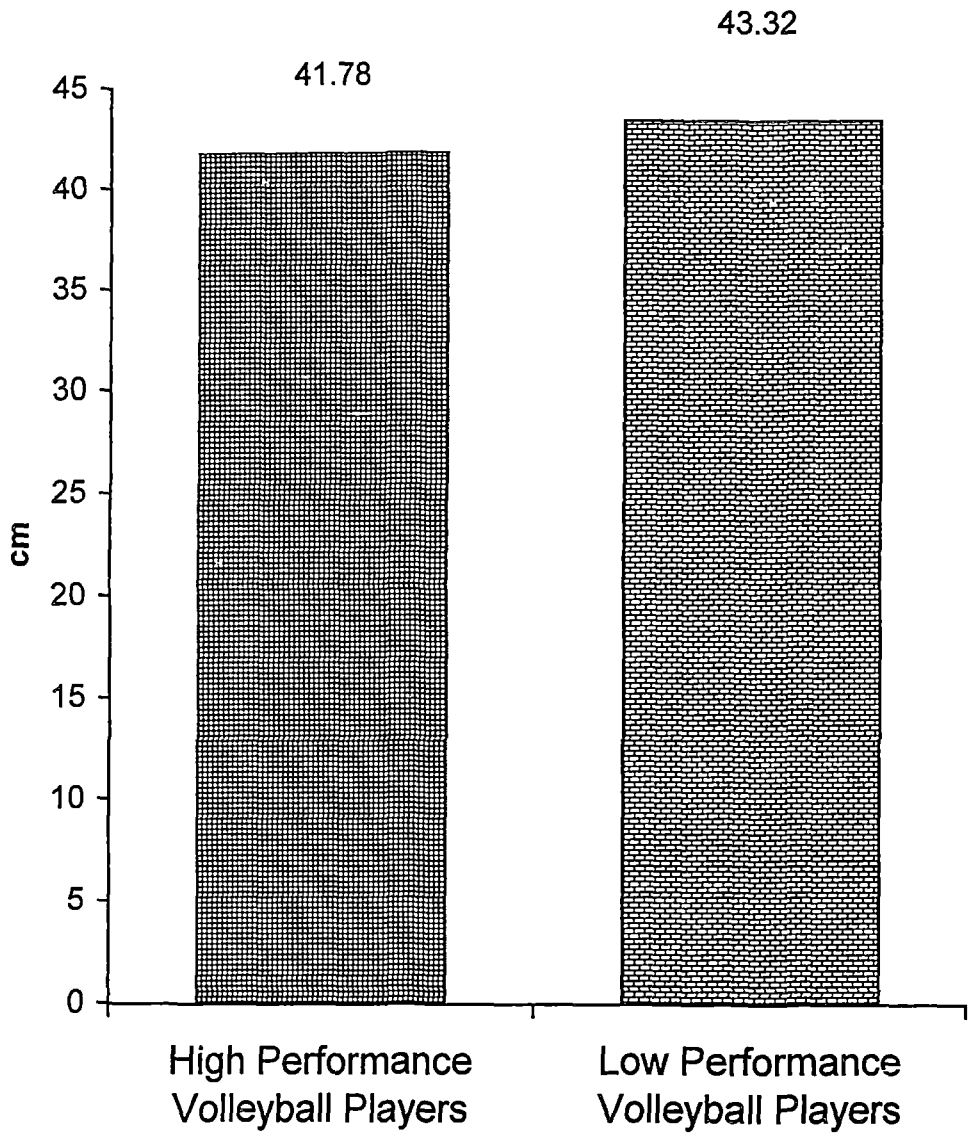

Fig. 32: The mean Total arm length – Upper arm length index of high and low performance volleyball players

Table (33) - Hand length – Wrist width index

Hand length – Wrist width index of High and Low performance volleyball players

Hand length – Wrist width index	High performance volleyball players	Low performance volleyball players
Mean	28.94	29.34
Standard Deviation	2.46	2.51
Obtained value $\|Z\|$	0.79	

* *Significant at 0.05 level*
** *Z value for one tail test to be significant at 0.05 level 1.64*

Table 33 Shows insignificant obtained Z-value for one tail test, which leads us to conclude that the mean hand length – wrist width index of high performance volleyball players is not significantly greater than the mean total arm length – lower arm length index of low performance volleyball players.

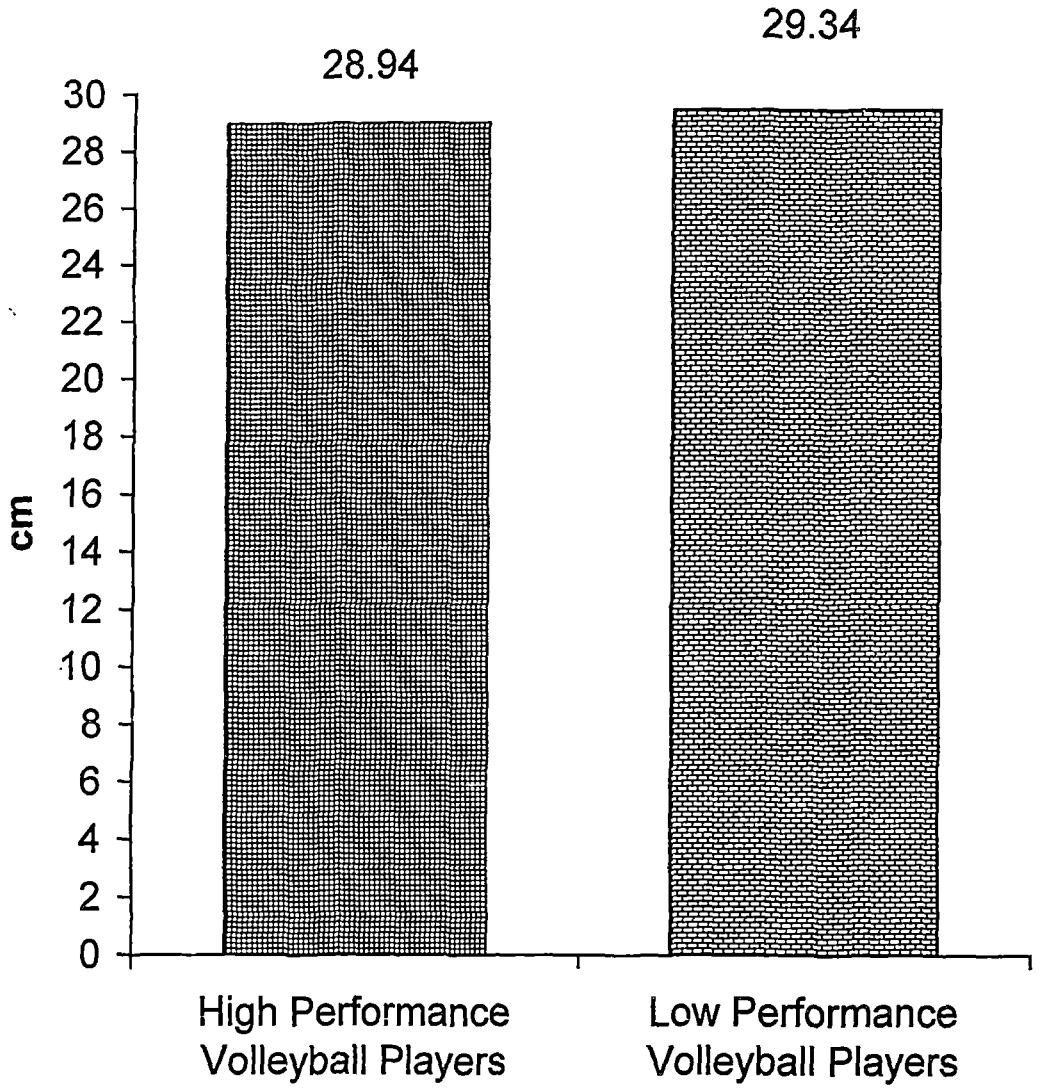

Fig. 33: The mean Hand length – Wrist width index of high and low performance volleyball players

DISCUSSION OF FINDINGS

The Z test analysis of data had revealed that significant difference exists between most of the Anthropometrical and Physiological variables of high and low performance volleyball players.

Weight

It is observed that mean weight of High performance volleyball players is significantly greater than low performance volleyball players.

Phul et al., in the year (1982), determined the physical characteristics of male Volleyball players and found that they were heavier and had a higher body density.

Similarly Hirata in (1966) conducted a study on 116 Olympic volleyball players and found that the average weight is 79.00kg, which is heavier than the control.

Greater weight signifies greater size in relation to size length and breadth of various body segments and lean body mass. Which gives greater strength and stability in comparison to low performance volleyball players.

Stature

It is observed that mean stature of High performance volleyball players is significantly greater than low performance volleyball players.

Sodhi; (1980) gathered data of different level of volleyball players and found that with increase in standard of the game the average stature of players was greater.

In another study John et al., in 1988, studied the physique of elite volleyball players and found that they had tall stature.

The greater height of high performance volleyball players provides them greater reach above the net and on the court, which is advantageous for them in spiking, blocking, defense and servicing.

Sitting height

It is observed that mean sitting height of High performance volleyball players is significantly greater than low performance volleyball players.

Sodhi et al. (1990) also conducted similar study on north Indian junior volleyball players aged 16-18 yrs. and found each age group having greater trunk length.

Mokha and Sidhu in (1988) took Anthropormetric measurement of International female volleyball players and found there sitting height to be geater than the controls.

The greater sitting height of high performance volleyball players provides them greater reach, which is advantageous for them in spiking, blocking, servicing and defense.

Femur biepic condyle diameter

It is observed that mean femur biepic condyle diameter of High performance volleyball players is significantly greater than low performance volleyball players.

Sodhi and Sidhu in (1984), observed that Indian national volleyball players had wider knees than low standard players.

The wider biepic condyle diameter signifies strong knees base, which provides greater muscular attachment. This signifies greater strength, mobility and stability along with protection from injuries. This helps the players in powerful jump and efficient movements on the court.

Humerus biepic condyle diameter

It is observed that mean humerus biepic condyle diameter of High performance volleyball players is significantly greater than low performance volleyball players.

Sodhi (1990) et al., conducted study on north Indian Junior volleyball players and found that the volleyballers in each group possessed considerably wider humerus than the controls.

This signifies strong elbow joint with bigger ligaments and tendons providing greater strength, stability, mobility and protection from injuries, which enhances their spiking, blocking and defence techniques.

Shoulder width

It is observed that mean shoulder width of High performance volleyball players is significantly greater than low performance volleyball players.

Hirata (1966) conducted a study on 116 Olympic volleyball players and found them to be having broader shoulder than the controls.

Greater shoulder width signifies greater muscular mass and bony area that provides the player with greater strength, stability and reach, which gives them advantage in attack and defence.

Hip width

It is observed that mean hip width of High performance volleyball players is significantly greater than low performance volleyball players.

The findings of our study are in line with the study of Hirata (1966), on 116 Olympic volleyball players where he observed them to have broader hip width than the controls.

Greater hip width signifies the greater surface area in relation to lean body mass that provides greater strength and base of support for upper body thus more stability, which is advantageous in defense, landing and take off.

Upper arm length

It is observed that mean upper arm length of High performance volleyball players is significantly greater than low performance volleyball players.

Hirata (1966) studied 116 Olympic volleyball players and found them to be tall and lean. They had greater upper arm length than the control.

Upper arm and lower arm length increases their reach above the net and on the court which helps them in spiking, blocking, boosting and defence.

Lower arm length

It is observed that mean lower arm length of High performance volleyball players is significantly greater than low performance volleyball players.

Sodhi et al., in (1990) studied Kinanthropometric characteristics of north Indian junior volleyball players and found them to be having greater length of hand.

Greater lower arm length gives them greater reach above the net, which helps them in spiking, blocking, defence, service and has greater power.

Thigh length and lower leg length

It is observed that mean thigh length and lower leg length of High performance volleyball players is significantly greater than low performance volleyball players.

The findings of our study are consistent with the findings of Mokha and Sidhu (1988) on Anthropometric measurement of Indian volleyball players who were having longer lower extremities than controls.

It is observed that high performance volleyball players had greater thigh and greater lower leg length in comparison to low performance volleyball players. Greater thigh and lower leg length signifies greater reach on the court due to higher center of gravity.

Biceps muscle girth

It is observed that mean biceps muscle girth of High performance volleyball players is significantly greater than low performance volleyball players.

Similarly Parvez Shamim in 2002 (Dec.) studied physical and physiological differentials between High and low performance basketball players, he observed greater biceps muscle girth in High performer than low performer.

Greater biceps muscle girth signifies greater strength in arm as cross sectional area is directly proportional to strength of muscles, which is advantageous in spiking, servicing and defence.

Calf muscle girth

It is observed that mean calf muscle girth of high performance volleyball players is significantly greater than low performance volleyball players

Sodhi et al's. (1990) Conducted a study on north Indian junior volleyball players in each age group and observed them to posses considerably greater calf circumference than the control.

Greater calf muscle girth signifies greater cross sectional area of muscles, thus more explosive power giving them greater advantage in their mobility on the court particularly in relation to Jump and leap.

Total skin fold ***(biceps, triceps, calf and suprailiac and sub-scapular)***

It is observed that mean total skin fold of high performance volleyball players is significantly lesser than low performance volleyball players.

In a somewhat similar study Mokha R. et al's from Punjabi University Patiala (India) examined six skin fold measurement (biceps,triceps,forearm, subscapular, suprailiac and calf) of 157 track and field athletes (42-throwers, 35-jumpers and 80 runners). Throwers possessed significantly more fat at all six sites than the jumpers and runners. Jumpers and runners did not differ much from each other.

Greater weight and lesser skin fold thickness signifies greater lean body mass in High performance volley ball players which shows their increased conditional ability in relation to speed strength, endurance and flexibility. This lesser fat in more strenuous training programme than their low % in high performers is also indicating towards their indulgence performance counterparts. Agbonjinmi(1998) also reported that measures of body-build and body composition of female college athletes have negative correlation with physical fitness index .It is well established that the athletes who are lean or less fatty but are heavy because of a well developed musculature, are superior in performance as compared to their fatty counterpart. Athletes with greater fat percentage have increased energy demand owing to their inert weight of fat resulting in relatively poor performance.

Wrist width

It is observed that mean wrist width of high performance volleyball players is significantly greater than the low performance volleyball players. Padopoulo S.D. (2000) examined 92 women's volleyball players from the national team (NT-n=29) and A1 division (AD-n=63),and found that the National team players had significantly greater wrist width than low performance counterparts.

Increase wrist width is directly proportional to strength, which helps in spiking, blocking and defense. It gives them advantage in flicking the ball in various directions, giving spin to the ball and also will provide greater area and stability for defense.

Hand length ***(Palm and Fingers)***

It is observed that mean hand length of high performance volleyball players is significantly greater than low performance volleyball players.

Similarly Sodhi et al. (1990) conducted a study on 116 Olympic volleyball players and observed that they had greater hand length than the controls. Greater hand length will help them in spiking, lifting, blocking, spinning and flicking .

Total arm length

It is observed that the mean total arm length of high performance volleyball players is significantly greater than low performance volleyball players.

Papadopoulo S.D. in (2000) examined 92 women volleyball players from National team and A1 division. The National Team Players had significantly greater upper limbs length than low performance players counter-parts.

Similarly Hirata Studied 116 Olympic volleyball players. He observed that Olympic players had greater upper limbs than their low performance counter parts. Greater total arm length provides greater reach above the net and on the court, which is advantageous in spiking, defense, serve, boost, spin and flicking etc.

Vital capacity

It is observed that mean vital capacity of High performance volleyball players is significantly greater than low performance volleyball players.

Newman & Carey et al. in (1955) observed that in swimming and diving the respiratory muscles are probably strengthened as they work against additional resistance caused by weight of water compressing the thoracic cage. Relatively large vital capacity has been reported for skin divers and competitive swimming.

In another study Kaufmann et al, in (1974), observed that lung volume of Olympic speed skaters tended to be larger than those of untrained healthy individual.

The volume of lung increases while training due to increase in the alveolar size and the capillary network surrounding the alveolar membrane this allows more intake of oxygen inside the lungs along with greater gaseous exchange due to enhanced capillary network.

Thus we are able to conclude that high performers are following a more vigorous training programme than their low performance counterparts. This enhanced lung volume is a vice versa factor.

Heart rate

It is observed that mean heart rate of high performance volleyball players is significantly lower than low performance volleyball players. Kjellberg et al., 1949, Oscai et al., (1968), found that the total blood volume and hemoglobin increases with training. The increased hemoglobin and blood volume improve the oxidative capacity and is thus correlated with increased VO_2 max and decreased heart rate during sub-maximal exercise following training (Ekblom et al, 1973; Fox et al, 1975; Frick, et al, 1963; Salfin et al, 1969).

The decreased heart Rate of High performance volleyball players is also due to increased cardiac output resulting from increased ventricular volume and cardiac hypertrophy resulting through chronic strenuous physical training. Endurance training improves myocardial strength, which contributes to stroke Power during systole (Frank L. Katch). At muscle level increased O_2 extraction from blood due to increased capillary network takes place. Oxygen consumption per kg. of muscle also decreases due to enhanced efficiency of muscles. As a result O_2 requirement per Kg. of muscles is decreased. This decreases blood requirement of muscles, which leads to decreased heart rate.

This is also indicating that the high performers are following more vigorous training schedule, which is giving them greater cardio respiratory efficiency.

Blood pressure ***(systolic and diastolic)***

The findings of our study indicate insignificant difference in blood pressure (systolic and diastolic) of High and Low performance volleyball players. This is evident from the fact that both the group of players were engaged in above minimal level of endurance work out needed for keeping blood pressure towards normal values of 80 mm Hg and 120mm Hg. This is supported by the studies of Collander E.B, et al, in (1988), Fleck S.J. in (1988) and Person A.C. et al, in the year (1988), that the resistance training exercise may cause a greater rise in blood pressure compared to lower intensity dynamic movement, but it does not seem that this form of training causes any long-term increase in resting blood pressure. It also appears that a regular programme of resistance training blunts the blood pressure response. Trained body builders, for example show smaller increases in systolic and systolic blood pressure with resistance exercise than both novice and untrained groups. The findings that regular resistance training benefited the resting Blood Pressure of border line hypertensive subjects complements these observations. Physiological significance according to related literature and the findings of our study is that the blood pressure of trained players increases lesser due to decreased heart rate. As the intensity of exercise increases so the blood requirement per. Kg muscles increases. The increase in blood requirement per Kg.of muscles for trained person will be lesser than untrained, thus lesser increase in the B.P. of trained than the untrained takes place .

Endomorphic rating

It is observed that mean endomorphic rating of low performance volleyball players is significantly greater (24.09%) than the low performance volleyball players.

Sodhi and Sidhu (1984), observed that the Indian volleyball players had less endomorphic rating than their low performance counterparts.

The less endomorphic rating signifies greater muscular mass and lesser fat mass which provides greater speed, agility, flexibility which helps them in spiking, blocking, diving ,defense etc.

Mesomorphic rating and ectomorphic rating

It is observed that the mean mesomorphic and ectomorphic rating of high performance volleyball players is not significantly greater than the low performance volleyball players.

Sodhi et al. (1990), conducted a study on the north Indian volleyball players and found that on average the volleyball player were found to be meso-ectomorph which is supportive of our hypothesis i.e. there is no difference in meso-ectomorphic rating of High and Low performance volleyball players.

Sitting height- Stature index

It is observed that mean sitting height stature index of low performance volleyball players is significantly greater (10.75%) than the high performance volleyball players. This means that high performance players had shorter trunk and greater leg length than their low performance counterparts.

Mokha and Sidhu (1988), also observed that Indian female volleyball players had greater upper and lower extremities than the controls.

A greater lower extremity provides greater mobility in relation to jump and reach on the court, which helps them in spiking, blocking, defence etc.

Total arm length – Hand length index

Which means that in proportion to total arm length, the hand length of high performance volleyball player is greater than low performance volleyball players.

Sodhi et al (1990) conducted a study on the north Indian junior volleyball players. The result of the study revealed that the volleyballers in each age group possessed greater size of hand span than the controls.

Greater hand span will help them in spiking, boosting, spinning and flicking the ball.

Total arm length – Lower arm length index

Which means that in proportion to total arm length, the lower arm length of high performance volleyball player is greater than low performance volleyball players?

Parvez Shamim (2002), conducted a similar study on physical and physiological parameters of High and Low performance basketball players, he observed that high performers have greater lower arm length than the low performance basketball players.

Greater lower arm length provides greater advantage in spiking, blocking and defence.

Total arm length – Upper arm length index

This means that in proportion to total arm length the upper arm length of High performance volleyball player is greater than low performance volleyball player.

Sodhi et al.(1990), conducted a study on north Indian junior volleyball players. The result of the study revealed that the volleyballers in each age groups possessed greater upper arm length than the controls.

Greater upper arm length provides greater reach on the court, which helps them in blocking and smashing.

These reviews of various research studies in light of our findings is leading us to conclude that the observed significant differences in the various Anthropometrical and Physiological variables of high and low performance volleyball players are decisive determinants of the performance limits binding

those players. Which is conforming the fact that competitive sports, demands event specific physical structure.

Top-level performance demands a particular type of body size, shape and proportion. Numerous researchers had observed high co-relations between the body profile of athletes and performance in specific tasks. Hirata had suggested that Nation with people whose general physique is limited to the characteristics of champions in certain events must concentrate their training program on those events only. Carter had also suggested that the athletes who wish to achieve success in sports at high level must compare their physique with Olympic athletes.

Thus our findings are setting guideline for Coaches and up-coming athletes for comparing their physical structure with the high performance volleyball players of our country. If their structure is inline with the high performers then they may also achieve their status, subject to the optimization of other factors.

Chapter - 5

Summary, Conclusion and Recommendation

SUMMARY, CONCLUSION AND RECOMMENDATION

The poor performance of Indian volleyball players at the international level has been a cause of great concern, especially to the coaches, physical educationists and sports scientists. Efforts have been made to improve the standard of our sportsmen for long, but little success has been achieved, so far, in this respect.

Body structure plays a very significant role in determining human movements. Structural variations in body segments affect its movements. A specific type of body structure predisposes human body to advantage in a specific type of movement. The segmental length and breadth determine the leverage, possessed by the body (position of fulcrum and various lengths of load and efforts arms), which, in turn affects the final out come of force, created by muscles and its ultimate exploitation, for the purpose of motions.

There are numerous factors that are responsible for the performance of volleyball players. Fundamental skills of volleyball like smashing, servicing, defense, boosting etc. requires a specific type of physique. The size, shape and form of the player are known to play a significant role in their performance. Along with these factors, performance in volleyball is also determined by certain physiological variables such as vital capacity, heart rate and blood pressure, which are the determinants of athlete's conditional abilities.

This study is an attempt to highlight the differences between high and low performance volleyball players in relation to their physical and physiological variables. It aims to find out the natural and nurtured traits of volleyball players, which makes them high or low performers.

Thus the aim of this study was to compare the selected anthropometrical and physiological parameters of high and low performance volleyball players.

For the purpose of this study two groups of 50 subjects each were selected randomly from high and low performance volleyball players of our country.

High performance volleyball players were selected from National tournaments, and all India Inter university winners and runners team.

Low performance volleyball players were randomly selected from Zonal inter-varsity, states and districts tournament.

The study was delimited to the following anthropometrical and physiological parameters.

Anthropometrical parameters: 1) Weight, 2) Stature, 3) Sitting height, 4) Femur bi-epicondyler diameter, 5) Humerus bi-epicondyler diameter, 6) Hip width, 7) Shoulder width, 8) Upper arm length, 9) Lower arm length, 10) Hand length, 11) Total arm length, 12) Wrist width, 13) Triceps skin fold, 14) Biceps skin fold, 15) Sub-scapular skin fold, 16) Suprailiac skin fold, 17) Calf skin fold, 18) Biceps muscle girth, 19) Calf muscle girth, 20) Thigh length 21) Lower leg length

Somatotype: 1) Ectomorphy, 2) Mesomorphy, 3) Endomorphy

Body proportionality: 1) Sitting height – Stature index, 2) Ponderal index, 3) Thigh length – Lower leg length index, 4) Upper arm length – Lower arm length index, 5) Hips width – Stature index, 6) Shoulder width – Stature index, 7) Lower arm length – Upper arm length index, 8) Total arm length – Hand length index, 9) Total arm length – Lower arm length index, 10) Total arm length – Upper arm length index, 11) Hand length – Wrist width index

Physiological parameters: 1) Blood pressure, 2) Heart rate, 3) Vital capacity.

The researcher had gone to various parts of India for gathering the relevant data, all standards equipments and techniques were used.

Z-test at 0.05 level of significance were used to find out the significant difference between the above-mentioned delimited variables of high and low performance volleyball players.

The findings of the statistical analysis revealed significant differences between the following variables of high and low performance volleyball players.

High performance volleyball players had greater weight (12.35%), height (5.36%), sitting height (4.48%), femur bi-epicondyler diameter (5.10%), humerus bi-epicondyler diameter (4.49%), shoulder width (6.49%), hips width (5.04%), upper arm length (5.68%), lower arm length (6.49%), wrist width (4.67%), hand length (6.05%), thigh length (6.77%), lower leg length (6.76%), biceps muscles girth (4.71%), calf muscles girth (2.75%), vital capacity (7.81%), total arm length (9.62%) than low performance volleyball players.

Somatotype wise high performance volleyball players and low performance volleyball players were ecto-mesomorphic, but if we analyse individual rating, high performers had greater ectomorphic and lesser endomorphic rating than low performance volleyball players

High performance volleyballs players had lower sum of five skin folds than low performance players.

High performance volleyball players had greater vital capacity and lower heart rate than low performance volleyball players.

Body proportionality wise, high performance volleyball players had better proportionality in relation to mechanical advantage. They had greater hip width-stature ratio and lower sitting height-stature ratio than low performance volleyball players.

No significant differences were found between ectomorphic rating, endomorphic rating, mesomorphic rating, sitting height-stature index, lower arm length – upper arm length index, hip width – stature index, shoulder width-stature index, ponderal index, total arm length – hand length index, total arm

length – lower arm length index, total arm length – upper arm length index, hand length – wrist width index.

The reviews of various research studies in light of our findings is leading us to conclude that the observed significant differences in the various anthropometrical and physiological variables of high and low performance volley ball players are decisive determinants of the performance limits binding these players. Which is confirming the fact that competitive sports, demand *event specific physical structure.*

Top-level performance demands a particular type of body size, shape and proportion. High co-relations between the body profile of athletes and performance in specific tasks had been observed by numerous researchers. Hirata had suggested that nation with people whose general physique is limited to the characteristics of champions in certain events must concentrate their training programme on those events only. Carter had also suggested that the athletes who wish to achieve success in sports at high level must compare their physique with Olympic athletes.

Thus our findings are setting guideline for coaches and up-coming athletes for comparing their physical structure with the high performance volleyball players of our country. If their structure is inline with the high performers then they may also achieve their status, subject to the optimization of other factors.

CONCLUSIONS

The findings of our study had led us to draw the following conclusions:

Anthropometrical

1. The high performance volleyball players had greater weight, height, sitting height, femur bi-epicondyle diameter, humerus bi-epicondyle diameter, shoulder width, hip width, upper arm length, thigh length, lower leg length, biceps muscle girth, calf muscle girth and hip width-stature index than low performance volleyball players.

2. High performance volleyball players had more ecto-mesomorphic rating than low performance volleyball players.

3. High performance volleyball players have better segmental proportionalities than low performance volleyball players.

4. There is no significant difference in ponderal index, thigh length-lower leg length index, upper arm length-lower leg length index and shoulder width-stature index of high and low performance volleyball players.

Physiological

1. High performance volleyball players had lower heart rate than low performance volleyball players.

2. High performance volleyball players had greater vital capacity than low performance volleyball players.

3. There is no significant difference in systolic and diastolic blood pressures of high and low performance volleyball players.

These differences in anthropometrical and physiological characteristics gives high performance volleyball players extra advantage in relation to physical and mechanical aspects of volleyball, hence leading them to achieve higher performance in the game.

RECOMMENDATIONS

In light of the findings of our study the following recommendations are made–

(1) The findings of the study should be taken into consideration while going for talent hunts for probable potential volleyball players.

(2) Along with anthropometrical and physiological parameters, psychological and mechanical parameters of high and low performance volleyball players should also be studied.

(3) Further, a study should be conducted to compare top Indian volleyball players with the rest of world selected volleyball players in relation to anthropometrical, physiological, and mechanical parameters.

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Appendix

S.No.	PARAMETRES	NAME OF THE SUBJECTS (High performance Indian Volleyball Players)									
		Y.SUBBA RAO ASIAN GAMES (ONGC) (1)	AVINESH YADAV ASIAN GAMES (ONGC) (2)	ABHIJEET BHATTACH. ASIAN GAMES (ONGC) (3)	RAHUL S.AMAVEKAR ASIAN GAMES (ONGC) (4)	RATISH ASIAN GAMES (ONGC) (5)	MITHLESH SINGH ASIAN GAMES (ONGC) (6)	AJAY MALLIIK S.NATIONAL (ONGC) (7)	SURESH KUM. Godra S.NATIONAL (ONGC) (8)	UTPAL NATH S. NATIONAL NFRly. (ASSAM) (9)	NIRANJAN S.NATIONAL (ASSAM) (10)
1	Weight (kg)	86	81	86	88	74	80	73	75	68	78
2	Stature (cm)	209	194	196	199	198	196	188	187	189	195
3	Sitting height (cm)	101	97	99	98	92	100	90	91	98	104
4	Femur biepic cond. di. (cm)	11	11	11	11	11	11	10	11	10	11
5	*Humerus biepic condyler di.,,*	*8*	*07*	*07*	*08*	*07*	*08*	*08*	*07*	*07*	*08*
6	Shoulder width (cm)	43	44	42	44	44	42	43	44	40	41
7	Hip width (cm)	30	30	30	31	28	29	29	31	29	30
8	Upper arm length (cm)	43	37	38	42	37	36	36	36	38	34
9	Lower arm length (cm)	35	31	30	33	31	30	30	27	31	28
10	Thigh length (cm)	58	50	51	55	51	51	50	48	45	49
11	Lower leg length (cm)	64	55	57	58	56	58	51	54	56	55
12	Bicep muscle girth (cm)	31	33	35	35	30	35	32	32	28	31
13	Calf muscle girth (cm)	37	37	37	39	35	38	34	34	37	37
14	Triceps skin fold (mm)	03	5	04	03	03	04	03	05	03	06
15	Sub-scapular skin fold (mm)	08	09	08	06	09	07	11	11	09	09
16	Supra-iliac skin fold (mm)	05	05	05	02	03	05	04	05	05	04
17	Calf skin fold (mm)	04	05	07	04	03	03	05	05	04	07
18	Bicep skin fold (mm)	03	04	03	02	03	03	04	04	03	06
19	Wrist width (cm)	06	07	06	07	06	07	06	06	06	06
20	Hand length (cm)	23	23	22	24	24	22	22	21	22	21
21	Total arm length (cm)	98	88	90	98	92	92	86	82	87	84
22	Heart rate (bts./min)	68	60	66	64	60	58	64	66	62	68
23	Blood pressure systolic&diastolic (mm/Hg)	120/80	120/80	120/70	120/70	110/70	130/80	110/90	110/170	130/70	130/90
24	Vital capacity (cc)	6000	6500	5500	6500	7000	6300	6000	6800	7000	6800

S.No.	PARAMETRES	NAME OF THE SUBJECTS (High performance Indian Volleyball Players)									
		UTPAL DEKA S.NATIONAL N.F. Railway (ASSAM) (11)	BIREN GOYARY S.NATIONAL (N.F.Rly.ASSAM) (12)	INDRANIL CHATTERJEE S.NATIONAL (W.BENGAL) (13)	SUDIPTA KUMAR S.NATIONAL (W.B.) (14)	DIPAK GHOSH S.NATIONAL (W.B.) (15)	RAMESH K. PUNDLA S.NATIONAL (ONGC) (16)	ASHISH JOSEPH AllUni.-Runn. (KERLA.Uni.) (17)	JAYACAC KJ S.NATIONAL (KERLA Uni.) (18)	PRADEEP KR. AllUni. – Runn. (KERLA Uni) (19)	KHARKHWDAC MUSHAHARY S.NATIONAL (ASSAM POLICE (20)
1	Weight (kg)	65	77	75	80	65	80	75	74	65	73
2	Stature (cm)	187	183	198	200	189	188	193	188	194	182
3	Sitting height (cm)	93	94	98	101	93	90	93	92	87	96
4	Femur biepic cond. di. (cm)	10	11	11	11	11	10	10	11	10	11
5	Humerus biepic condyler di.,,	07	08	07	O8	07	07	08	07	07	08
6	Shoulder width (cm)	40	40	42	44	42	42	43	41	40	43
7	Hip width (cm)	28	29	29	30	29	30	29	28	26	28
8	Upper arm length (cm)	35	36	37	39	38	37	38	36	35	35
9	Lower arm length (cm)	30	29	33	31	31	29	31	29	30	29
10	Thigh length (cm)	47	45	50	52	49	45	53	47	51	45
11	Lower leg length (cm)	55	54	60	58	54	53	55	52	58	43
12	Bicep muscle girth (cm)	28	34	29	31	29	32	33	30	32	33
13	Calf muscle girth (cm)	35	38	35	34	34	36	36	33	33	36
14	Triceps skin fold (mm)	05	04	03	05	03	03	05	04	04	05
15	Sub-scapular skin fold (mm)	08	08	07	08	07	09	10	11	07	08
16	Supra-iliac skin fold (mm)	04	05	04	05	04	10	09	05	04	05
17	Calf skin fold (mm)	05	04	05	04	04	04	07	04	06	04
18	Bicep skin fold (mm)	04	03	04	03	03	04	03	03	03	03
19	Wrist width (cm)	06	06	06	07	06	06	06	06	07	06
20	Hand length (cm)	20	22	23	22	22	22	23	21	22	22
21	Total arm length (cm)	84	84	90	92	88	85	90	93	86	83
22	Heart rate (bts./min)	60	64	64	62	64	70	62	60	66	60
23	Blood pressure systolic&diastolic (mm/hg)	120/80	130/80	130/70	130/90	130/80	120/80	120/80	120/70	120/80	130/90
24	Vital capacity (cc)	6800	7300	5500	6500	6400	6400	6000	7000	6800	6500

S No	PARAMETRES	NAME OF THE SUBJECTS (High performance Indian Volleyball Players)									
		RJNGCHAD CH. BR.NARZARY S NATIONAL (ASSAM POLICE) (21)	JAVED KHAN NATIONAL H N B G Uni (DEHRADUN) (22)	TRIVENDRA Kr. SINGH NATIONAL N F RLY (GORAKHPUR) (23)	DAVINDER SINGH NATIONAL G N D U (AMRITSAR) (24)	SUMIRAN DAS S NATIONAL (ASSAM) (25)	RAJIV GAUR S NATIONAL H N B G Uni (DEHRADUN) (26)	MANISH MADAN S.NATIONAL H N B G Uni (DEHRADUN) (27)	TEOPACHAN SINGH S NATIONAL G N D U (AMRITSAR) (28)	PARNJIT SINGH NATIONAL G N D U (AMRITSAR) (29)	VIKASH SINGH RANA S NATIONAL Spts HOSTEI (ALLAHABAD) (30)
1	Weight (kg)	75	64	73	75	65	64	75	76	75	78
2	Stature (cm)	190	189	188	190	183	188	193	189	189	188
3	Sitting height (cm)	99	94	89	90	93	93	98	95	94	94
4	Femur biepic cond. di. (cm)	11	10	10	10	09	09	10	11	11	09
5	Humerus biepic condyler di.,,	07	07	07	08	07	07	08	08	08	07
6	Shoulder width (cm)	41	40	39	43	40	42	42	41	42	41
7	Hip width (cm)	31	27	29	28	28	29	30	31	29	29
8	Upper arm length (cm)	35	28	38	39	33	36	36	36	33	36
9	Lower arm length (cm)	28	26	30	30	28	29	29	29	29	29
10	Thigh length (cm)	47	48	49	51	44	48	49	49	49	50
11	Lower leg length (cm)	43	56	55	55	53	54	54	51	55	54
12	Bicep muscle girth (cm)	31	29	30	33	29	29	29	31	30	32
13	Calf muscle girth (cm)	35	33	34	34	33	34	35	36	38	36
14	Triceps skin fold (mm)	04	03	05	07	04	04	08	10	06	06
15	Sub-scapular skin fold (mm)	08	05	08	09	08	07	10	12	09	08
16	Supra-iliac skin fold (mm)	04	04	05	04	03	03	07	08	06	05
17	Calf skin fold (mm)	04	06	06	06	03	03	05	08	08	06
18	Bicep skin fold (mm)	03	03	05	05	03	03	05	06	04	04
19	Wrist width (cm)	06	06	06	06	06	06	06	07	07	06
20	Hand length (cm)	21	22	22	22.5	22	21	22	22	23	21
21	Total arm length (cm)	83	88	86	89	82	87	91	88	86	90
22	Heart rate (bts./min)	66	66	66	62	64	68	64	64	62	58
23	Blood pressure systolic&diastolic (mm/hg)	130/80	120/80	110/80	130/90	120/80	120/80	120/80	130/80	130/80	110/75
24	Vital capacity (cc)	5500	6100	6500	6800	5400	7200	7100	7400	6000	6800

S.No.	PARAMETRES	NAME OF THE SUBJECTS (High performance Indian Volleyball Players)									
		VIRENDRA S. S NATIONAL (CHANDIGARH) (31)	UDAY RAJ YADAV S NATIONAL (DLW VARANSI) (32)	PAVAN KUMAR YADAV S NATIONAL (SAI ALLAHABAD) (33)	V.P. ANAND S NATIONAL (N F RLY) (34)	SARVAJEET MISHRA S NATIONAL (N F RLY) (35)	ANUVIR SINGH S NATIONAL D L W (VARANSI) (36)	NEARP R. GILL NATIONAL D L W (VARANSI) (37)	ASHOK Kr. ROY S NATIONAL D L W (VARANSI) (38)	AMARJEET SINGH AllUni G N D U (AMRITSAR) (39)	PARAMJEET SINGH AllUni G N D U (AMRITSAR) (40)
1	Weight (kg)	82	84	67	71	69	65	68	66	71	77
2	Stature (cm)	180	186	175	180	182	178	182	174	182	187
3	Sitting height (cm)	89	92	91	93	87	89	88	88	87	95
4	Femur biepic cond. di. (cm)	11	10	10	10	10	10	10	10	09	10
5	Humerus biepic condyler di.,,	07	08	08	07	07	08	07	07	08	08
6	Shoulder width (cm)	41	43	40	40	43	39	40	41	40	45
7	Hip width (cm)	30	28	28	27	28	27	28	27	27	29
8	Upper arm length (cm)	34	33	35	34	38	27	38	31	34	35
9	Lower arm length (cm)	28	29	26	26	29	25	28	25	28	29
10	Thigh length (cm)	46	49	44	46	46	44	46	45	48	44
11	Lower leg length (cm)	51	52	52	54	55	49	50	50	52	56
12	Bicep muscle girth (cm)	33	34	30	31	30	29	31	30	32	31
13	Calf muscle girth (cm)	40	38	34	36	36	35	36	36	34	37
14	Triceps skin fold (mm)	08	04	08	05	05	07	05	07	03	05
15	Sub-scapular skin fold (mm)	12	10	10	10	10	08	08	12.5	08	10
16	Supra-iliac skin fold (mm)	11	07	05	06	06	06	04	09	05	05
17	Calf skin fold (mm)	05	06	07	08	06	06	05	08	07	03
18	Bicep skin fold (mm)	05	03	06	04	05	04	02	05	05	03
19	Wrist width (cm)	06	06	06	06	07	07	06	07	07	07
20	Hand length (cm)	22	22	21	20	20	20	21	20	22	22
21	Total arm length (cm)	80	83	79	81	79	79	80	79	84	86
22	Heart rate (bts./min)	62	68	78	64	66	58	72	58	70	72
23	Blood pressure systolic&diastolic (mm/Hg)	120/80	120/80	120/80	120/80	120/90	110/70	110/80	110/70	140/100	130/80
24	Vital capacity (cc)	6400	6200	6500	6200	6300	6000	6300	6800	6800	6000

S.No.	PARAMETRES	NAME OF THE SUBJECTS (High performance Indian Volleyball Players)									
		MANOJ Kr. SINGH NATIONAL OPEN D.L.W. (VARANSI) (41)	PRAKASH SINGH J.NATIONAL SAI. (RAIBARELIE) (42)	MD..AJMAL NATIONAL (VARANSI) (43)	ANJANI Kr. PANDAY D.L.W. (VARANSI) (44)	SUKHBINDAR SINGH AllUni.GNDU. (AMRITSAR) (45)	GANESH VIDYARTHI INTER Univ. (GADHWAL) (46)	KRISHNA KUMAR SINGH N.Rly. (LUCKNOW) (47)	AMANDEEP SINGH A.II.UNI. (JALANDHAR) (48)	SAPINDER PAL SINGH AllUni. (PANJAB Univ) (49)	ANAND SHARMA NATIONAL (RAIBARELIE (50)
1	Weight (kg)	70	69	71	71	74	75	77	70	65	85
2	Stature (cm)	180	182	186	180	182	186	185	183	186	187
3	Sitting height (cm)	90	92	92	89	88.5	91.5	95	88	96	93
4	Femur biepic cond. di. (cm)	10	10	10	11	10	09	10	09	10	11
5	Humerus biepic condyler di.,,	08	07	08	07	08	07	07	07	07	08
6	Shoulder width (cm)	39	42	42	40	43	42	42	43	43	41
7	Hip width (cm)	27	26	30	29	27	28	30	28	30	30
8	Upper arm length (cm)	35	33	36	36	35	37	36	36	35	36
9	Lower arm length (cm)	27	28	28	27	28	30	28	30	30	30
10	Thigh length (cm)	46	46	49	55	46	49	46	50	44	47
11	Lower leg length (cm)	50	53	53	52	51	54	51	52	56	56
12	Bicep muscle girth (cm)	31	31	29	31	30	32	31	32	28	33
13	Calf muscle girth (cm)	37	36	35	36	37	35	39	35	36	41
14	Triceps skin fold (mm)	10	05	07	04	06	07	06	05	06	12
15	Sub-scapular skin fold (mm)	14	13	10	05	05	13	13	10	08	13
16	Supra-iliac skin fold (mm)	05	04	05	05	05	09	06	06	04	05
17	Calf skin fold (mm)	05	09	04	08	06	09	08	05	08	06
18	Bicep skin fold (mm)	04	04	04	03	05	07	05	04	03	06
19	Wrist width (cm)	06	06	07	06	07	06	06	06	06	06
20	Hand length (cm)	20	21	22	20	21	22	22	22	23	23
21	Total arm length (cm)	81	82	86	78	86	83	84	81	84	88
22	Heart rate (bts./min)	68	70	62	60	72	60	70	64	60	60
23	Blood pressure systolic&diastolic (mm/Hg)	120/80	120/90	110/90	120/80	130/90	120/80	130/90	120/70	110/70	130/90
24	Vital capacity (cc)	6800	6500	7200	6300	6000	5600	6500	6000	6000	5500

S.No.	PARAMETRES	NAME OF THE SUBJECTS (Low performance Indian Volleyball Players)									
		OM PRKASH PATEL SCH.NATIONAL (ALLAHABAD) (1)	SANJAY SINGH STATE (FAIZABAD) (2)	SUNEET MITRA PANDAY STATE (FAIZABAD) (3)	DANANJAY ROY (J.NATIONAL) (4)	KULDEEP VARMA YOUTH NAT (GADHWAL) (5)	AMIT Kr. PANDAY YOUTH NAT. (ALLAHABAD) (6)	GURTEJ SINGH ALL. I. UIN. G.N.D.U. (AMRITSAR) (7)	BALDEV SINGH (INTER UNIV.) G.N.D.U. (AMRITSAR) (8)	ABHISHEK AGGARWAL AIIU HNBGUni. (DEHRADUN) (9)	VIKASKAJLA S.J. NATIONAL HNBGUni. (DEHRADUN) (10)
1	Weight (kg)	58	70	60	59	56	80	62	63	93	59
2	Stature (cm)	173	179	180	173	175	188	179	176	181	181
3	Sitting height (cm)	85	88	86	83	87	94	84	86	89	94
4	Femur biepic cond. di. (cm)	10	10	09	09	09	10	10.5	10	11	09
5	Humerus biepic condyler di.,,	07	08	07	07	06.5	08	07	07	08	07
6	Shoulder width (cm)	38	40	38	38	41	44	39	40	43	40
7	Hip width (cm)	26	28	26	26	26	28	27	26	31	29
8	Upper arm length (cm)	32	34	25	35	35	37	33	33	34	33
9	Lower arm length (cm)	26	27	28	26	26	30	27	26	28	30
10	Thigh length (cm)	46	46	46	46	46	47	43	46	48	44
11	Lower leg length (cm)	50	51	53	50	49	54	51	49	41	49
12	Bicep muscle girth (cm)	28	32	28	29	26	32	30	31	39	28
13	Calf muscle girth (cm)	35	36	32	34	31	38	33	34	41	33
14	Triceps skin fold (mm)	04	12	05	05	05	12	04	08	27	05
15	Sub-scapular skin fold (mm)	10	13	06	09	13	14	08	10	24	08
16	Supra-iliac skin fold (mm)	04	06	04	07	07	06	04	06	08	05
17	Calf skin fold (mm)	07	08	06	06	08	06	08	09	10	06
18	Bicep skin fold (mm)	04	05	03	04	03	05	04	05	08	04
19	Wrist width (cm)	06	07	06	06	06	06	06	06	07	06
20	Hand length (cm)	20	22	21	20	20	22	22	19	21	20
21	Total arm length (cm)	70	77	78	70	72	86	80	70	80	74
22	Heart rate (bts./min)	66	68	64	66	68	72	72	70	66	72
23	Blood pressure systolic&diastolic (mm/Hg)	120/90	130/90	130/90	110/70	140/90	130/80	110/80	110/80	130/90	120/80
24	Vital capacity (cc)	5500	6200	6500	5600	5800	5600	6000	5000	6300	6400

S.No.	PARAMETRES	NAME OF THE SUBJECTS (Low performance Indian Volleyball Players)									
		GULMOHAMMAD INTER Univ (A M U ALIGARH) (11)	MD IMRAN INTER Uni A M U (ALIGARH) (12)	SHARAD CHAUDHARY AllUni LNIPE (GWALIOR) (13)	AMIT SINGH BHADORIA AllUni LNIPE (GWALIOR) (14)	VINIT KUMAR AllUni LNIPE (GWALIOR) (15)	NITIN CHAUDHRY AllUni LNIPE (GWALIOR) (16)	BHAARTENDO SHEKHAR PND AllUni LNIPE (GWALIOR) (17)	AMAR Kr. AllUni LNIPE (GWALIOR) (18)	VIJAY Kr. AllUni LNIPE (GWALIOR) (19)	RAJESH DHUTHA AllUni LNIPE (GWALIOR) (20)
1	Weight (kg)	68	62	67	64	74	65	65	63	71	63
2	Stature (cm)	185	174	177	177	191	182	177	182	183	174
3	Sitting height (cm)	90	86	91	92	94	92	92	90	95	88
4	Femur biepic cond. di. (cm)	10	10	10	09	10	10	10	09	10	09
5	Humerus biepic condyler di.,,	07.5	07	07	07	07	07	07	07	07	07
6	Shoulder width (cm)	36	40	40	40	42	41	38	38	22	40
7	Hip width (cm)	30	27	28	28	30	27	27	27	29	29
8	Upper arm length (cm)	35	33	34	34	37	33	34	36	34	33
9	Lower arm length (cm)	29	28	27	27	30	27	27	29	27	25
10	Thigh length (cm)	48	45	44	41	49	45	44	45	43	42
11	Lower leg length (cm)	54	50	49	53	55	51	51	52	51	49
12	Bicep muscle girth (cm)	29	29	30	32	29	28	29	29	31	29
13	Calf muscle girth (cm)	37	34	34	37	35	35	38	33	36	35
14	Triceps skin fold (mm)	04	03	07	04	05	04	05	04	04	03
15	Sub-scapular skin fold (mm)	06	04	12	09	10	08	09	07	09	07
16	Supra-iliac skin fold (mm)	05	03	06	05	07	04	06	04	05	03
17	Calf skin fold (mm)	07	04	07	11	12	05	08	04	06	05
18	Bicep skin fold (mm)	03	02	04	04	04	02	04	03	04	03
19	Wrist width (cm)	07	06	06	05	06	06	06	06	06	05
20	Hand length (cm)	22	21	20	21	23	20	20	20	22	19
21	Total arm length (cm)	79	70	79	79	88	78	80	83	81	76
22	Heart rate (bts./min)	74	56	64	74	60	70	60	72	68	76
23	Blood pressure systolic&diastolic (mm/Hg)	110/70	115/60	130/90	110/70	130/80	130/90	130/80	130/80	120/90	110/70
24	Vital capacity (cc)	5500	6000	5100	5800	6000	6000	6000	6000	6100	5800

S.No.	PARAMETRES	NAME OF THE SUBJECTS (Low performance Indian Volleyball Players)									
		SAMEER YADAV AllUni LNIPE (GWALIOR) (21)	RANJAN SHARMA AllUni INDORE(M P) (22)	PADAM RAJ RATHORE AllUni INDORE(M P) (23)	PANKAJ AllUni INDORE(M P) (24)	AMIT SRIVASTAVA AllUni INDORE(M P) (25)	BHARAT RAGHUVASHI AllUni INDORE(M P) (26)	AJIT PAL SINGH AllUni INDORE(M P) (27)	SACHIDANAND SINGH AllUni (M G K V P) (28)	MARITUNJAY RAJ INTER UNIVR (VARANSI) (29)	AJAY SHARMA AllUni LNIPE (GWALIOR) (30)
1	Weight (kg)	61	74	74	56	65	68	76	68	62	73
2	Stature (cm)	173	180	175	172	180	167	176	174	175	190
3	Sitting height (cm)	89	90	87	88	86	84	88	86	88	95
4	Femur biepic cond. di. (cm)	10	10	10	10	10	10	10	10	09	10
5	Humerus biepic condyler di.,,	07	08	07	07	07	07	07	07	07	07
6	Shoulder width (cm)	39	42	39	38	37	40	41	39	40	41
7	Hip width (cm)	27	28	28	25	27	26	30	27	28	29
8	Upper arm length (cm)	33	35	33	32	35	30	35	34	33	36
9	Lower arm length (cm)	28	27	26	27	27	26	28	27	25	29
10	Thigh length (cm)	43	45	43	44	47	42	47	45	42	49
11	Lower leg length (cm)	48	52	49	48	51	48	51	50	49	53
12	Bicep muscle girth (cm)	28	31	32	28	29	31	34	29	29	28
13	Calf muscle girth (cm)	34	38		32	36	35	37	33	35	36
14	Triceps skin fold (mm)	04	09	09	04	10	08	14	09	06	05
15	Sub-scapular skin fold (mm)	08	15	14	08	13	12	24	13	10	06
16	Supra-iliac skin fold (mm)	05	10	11	05	10	13	18	07	05	05
17	Calf skin fold (mm)	08	14	09	05	16	08	12	06	06	06
18	Bicep skin fold (mm)	04	06	08	04	06	07	10	06	04	03
19	Wrist width (cm)	05	06	06	06	06	07	06	06	05	07
20	Hand length (cm)	20	21	20	21	20	20	21	18	19	21
21	Total arm length (cm)	79	82	78	81	84	77	82	80	76	85
22	Heart rate (bts./min)	76	68	78	74	72	70	78	70	74	58
23	Blood pressure systolic&diastolic (mm/Hg)	130/100	130/80	140/90	130/90	130/90	120/80	140/100	120/90	130/90	120/80
24	Vital capacity (cc)	6100	5800	5700	6200	5800	6200	5300	6500	6000	5500

S. No.	PARAMETRES	NAME OF THE SUBJECTS (Low performance Indian Volleyball Players)									
		R.KAMRAJ S NATIONAL (ONGC) (31)	ANURAG E.P S.NATIONAL (W.B) (32)	PROSENJIT KUNDU NATIONAL (W.B.) (33)	NAUSHAD MANSOORY S.NATIONAL INDORE(M.P) (34)	DEBASIS HAZRA NATIONAL (W.B.) (35)	ANWAR HUSSAIN NATIONAL (ASSAM) (36)	DHARMJEET UZAIR NATIONAL (ASSAM) (37)	ABHISHEKH PANDAY S.J.NATIONAL (MURADABAD) (38)	SURENDRA YADAV NATIONAL (VARANSI) (39)	SUNIL KUMAR ROY Y.NATIONAL (VARANSI) (40)
1	Weight (kg)	58	62	67	64	65	64	75	65	75	66
2	Stature (cm)	174	173	170	174	184	186	185	180	182	176
3	Sitting height (cm)	88	90	90	87	95	96	93	91	89	88
4	Femur biepic cond. di. (cm)	10	10	10	09	10	10	10	10.5	11	09
5	Humerus biepic condyler di.,,	07	07	07	07	08	07	07	07	08	07
6	Shoulder width (cm)	38	40	40	39	42	42	40	40	42	41
7	Hip width (cm)	26	26	27	26	26	29	28	28	30	27
8	Upper arm length (cm)	35	31	33	36	36	35	36	36	26	35
9	Lower arm length (cm)	27	27	27	28	30	28	29	27	29	26
10	Thigh length (cm)	45	46	47	45	47	46	48	46	48	43
11	Lower leg length (cm)	50	47	44	51	50	51	53	53	54	52
12	Bicep muscle girth (cm)	28	30	31	30	30	28	31	30	32	29
13	Calf muscle girth (cm)	32	34	35	34	33	35	34	34	38	35
14	Triceps skin fold (mm)	04	03	04	05	04	03	06	07	07	08
15	Sub-scapular skin fold (mm)	07	13	10	08	08	07	11	10	12	14
16	Supra-iliac skin fold (mm)	04	06	06	05	05	03	06	05	11	08
17	Calf skin fold (mm)	04	05	05	05	05	03	10	05	05	06
18	Bicep skin fold (mm)	03	03	04	04	03	02	03	04	05	05
19	Wrist width (cm)	06	06	06	05	07	06	06	07	06	05
20	Hand length (cm)	19	20	20	21	21	20	21	21	22	18
21	Total arm length (cm)	79	76	78	81	85	81	83	81	76	76
22	Heart rate (bts./min)	60	62	68	62	62	70	66	62	64	72
23	Blood pressure systolic&diastolic (mm/Hg)	110/70	120/80	120/80	120/80	140/80	120/90	130/80	110/70	130/100	140/100
24	Vital capacity (cc)	6500	5700	5700	6500	5200	6600	6300	5800	6700	5500

S.No.	PARAMETRES	NAME OF THE SUBJECTS (Low performance Indian Volleyball Players)									
		SHAJEER AllUni.Runner (KERLA Uni.) (41)	SANJRI LARKAN S NATIONAL (ASSAM) (42)	SUMENDRA BHADUR SINGH SJ.NATIONAL (MURADABAD) (43)	SUSHIL Kr. RAI (J.NATIONAL) (44)	DURGESH PRATAP SINGH (STATE) (45)	AMIT KR. SINGH (STATE) (46)	DHANANJAY KR. ROY J.NATIONAL S.A.I.RAIBARELY (47)	VIKRANT MISHRA J.NATIONAL SPORTS HOSTEL (FAIZABAD) (48)	BHUPINDRA SINGH (INTER Uni.) (49)	MD.IRSHAD ANSARI AllUni. (ALLAHABAD) (50)
1	Weight (kg)	53	69	59	68	68	65	57	61	64	56
2	Stature (cm)	172	176	180	182	182	181	172	180	179	169
3	Sitting height (cm)	87	93	94	88	87	90	85	88	88	86
4	Femur biepic cond. di. (cm)	09	10	10	10	10	10	09	10	10	09
5	Humerus biepic condyler di.,,	07	07	08	07	07	07	07	07	07	6.5
6	Shoulder width (cm)	41	39	39	41	39	41	39	38	41	39
7	Hip width (cm)	26	27	28	27	27	27	26	26	27	25
8	Upper arm length (cm)	35	31	33	38	36	36	32	35	33	33
9	Lower arm length (cm)	28	25	28	28	30	28	27	27	26	26
10	Thigh length (cm)	46	41	46	46	46	46	43	44	46	43
11	Lower leg length (cm)	47	50	50	50	50	52	50	52	50	48
12	Bicep muscle girth (cm)	28	29	29	31	31	31	28	28	29	25
13	Calf muscle girth (cm)	31	36	33	36	35	35	36	37	34	33
14	Triceps skin fold (mm)	03	07	04	05	10	06	08	04	06	04
15	Sub-scapular skin fold (mm)	07	17	07	09	10	10	06	06	07	11
16	Supra-iliac skin fold (mm)	04	11	05	04	08	05	06	03	06	05
17	Calf skin fold (mm)	03	12	03	08	07	04	05	06	07	06
18	Bicep skin fold (mm)	03	05	03	03	05	04	04	03	04	04
19	Wrist width (cm)	05	05	06	06	06	07	06	06	07	06
20	Hand length (cm)	20	20	20	21	20	21	20	22	22	20
21	Total arm length (cm)	80	75	78	80	76	78	70	76	78	68
22	Heart rate (bts./min)	60	68	60	66	56	64	60	62	64	64
23	Blood pressure systolic&diastolic (mm/Hg)	170/80	120/80	120/80	110/80	110/70	130/80	120/80	120/80	120/70	120/90
24	Vital capacity (cc)	5000	6000	6000	6000	6500	6300	6300	5400	6500	5000